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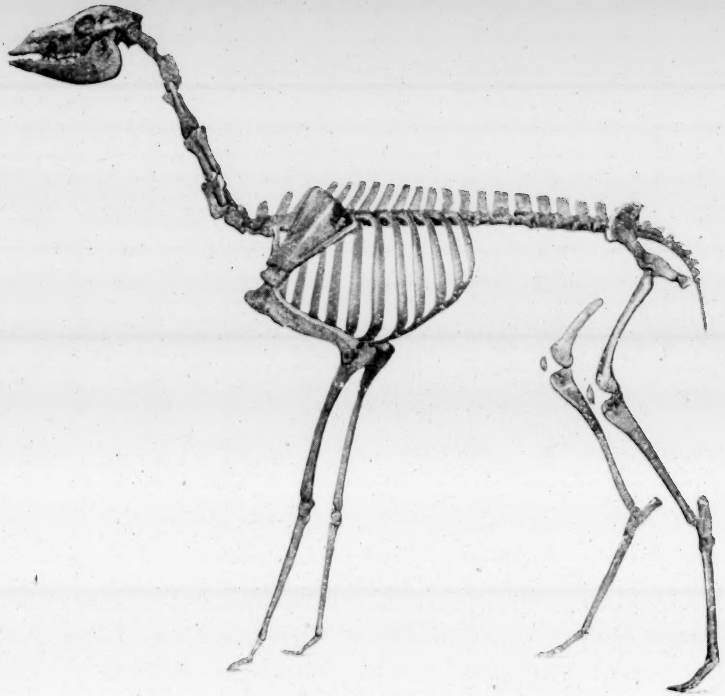

L. E. Parsons, Junr., photo. Bale & Sons, Ltd.

RESTORED SKELETON OF STENOMYLUS HITCHCOCKI. *Loomis.*

(About one-tenth natural size.)

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE VI. VOL. III.

No. I.—JANUARY, 1916.

ORIGINAL ARTICLES.

I.—Note on a Mounted Skeleton of a 'Gazelle-Camel', *Stenomylus hitchcocki*, Loomis.

By C. W. Andrews, D.Sc., F.R.S., British Museum (Natural History).

(PLATE I.)

(Published by permission of the Trustees of the British Museum.)

THERE has recently been exhibited in the Gallery of Fossil Mammals at the Natural History Museum a restored skeleton of *Stenomylus hitchcocki*, Loomis, a 'gazelle-camel' from the Lower Miocene of Nebraska. This specimen (M 10969), which has been mounted in relief by Mr. L. E. Parsons, jun., includes portions of the skeletons of two individuals, but much of the dorsal region of the vertebral column and the ribs have been restored in plaster. The remains are from the Lower Harrison Beds (Lower Miocene) near Agate Springs, Co. Nebraska, where upwards of forty skeletons were collected in a small area. Many were complete and lay in such a position that they are believed to be the remains of a herd overtaken by floods and drowned.

Stenomylus was an extremely slender gazelle-like animal, differing widely from the usual conception of a camel. Its canines and first premolars are incisiform, the molars low-crowned. The neck and limbs are slender and much elongated, and the metapodials are not yet united to form cannon-bones. This type of camel seems to have been confined to the Lower Miocene of North America.

The history of the sub-order Tylopoda (Camels) is a remarkable one. At the present day it is represented by one family only, the Camelidæ, and of this there are only two genera, one, *Camelus*, confined to Central Asia, the other, *Auchenia*, to the westernmost and southernmost parts of South America. When a group is thus represented by a few widely separated forms it may usually be assumed that it is the remnant of a formerly much more extensive assemblage which attained its maximum development in some region from which the few surviving forms have been derived. In the case of the Tylopoda this region was North America, where in the Tertiary period the group attained a great variety of form and where it survived in considerable numbers even to the Middle Pleistocene. During the Pliocene representatives had migrated into Asia and South America, and it is curious that although camels and llamas coexisted in North America no true camels reached South America and no llamas passed into Asia. This may perhaps have been because the camels, being

more tolerant of cold, were alone able to pass into North-Eastern Asia, while the llamas of the time were better fitted to pass through the Tropics to South America, where fossil forms have been found in Ecuador and Brazil. In the later Pleistocene the group became totally extinct in North America, hence its peculiar discontinuous distribution at the present day.

The earliest genus that can with certainty be referred to the Tylopoda is *Protylopus* from the Upper Eocene (Uinta). This genus includes animals about the size of a hare, in which the full dentition of 44 teeth was present, the bones of the fore-arm were separate, the fibula was complete, and there were four functional digits in each foot. In the White River Beds (Lower Oligocene) the genus *Poëbrotherium* is represented by several species, some of which attained the size of a sheep. In this genus also the full dentition was present, but the selenodont molars were becoming high-crowned, the fibula was incomplete, and there were only two functional digits in each foot, although remnants of the others persisted. Up to this stage, according to Professor W. B. Scott, only one phylum is traceable, but in the Lower Miocene the group gives rise to two side branches, one, the gazelle-camels, of which *Stenomylus* is a representative, and the other, the curious giraffe-camels, which, as their name implies, possessed very long neck and limbs and probably browsed on trees like giraffes. The earlier (Lower Miocene) form *Oxydactylus* was much smaller than the later *Alticamelus*, and its neck and limbs were less elongated. The grazing camels, which may be regarded as the main stock of the group, possessed selenodont molars with increasingly high crowns, and in the later forms both in this group and in the giraffe-camels the metapodials fuse to form cannon-bones, the bones of the fore-arm unite, and the fibula is greatly reduced. *Procamelus* of the Upper Miocene of North America seems to represent approximately the common ancestor of camels and llamas. The earliest members of the sub-order yet found in the Old World are from the Lower Pliocene of the Siwalik Hills; other forms existed in the late Pleistocene and perhaps in Neolithic times in Northern Africa. In Europe remains of Pleistocene camels have been found in Southern Russia and Rumania.

II.—Trail and Underplight.

By R. M. Deeley, M.Inst.C.E., F.G.S.

THE peculiar features presented by the upper or land-surface portions of some deposits, or rather those portions of certain deposits which are now, or have been in times past, land-surfaces, have engaged the attention of many geologists. Most of those who have studied them are satisfied that some features which they often show are not now being produced in this country, and they are attributed by many observers to the action of different climatic conditions to those which at present exist.

The form of disturbed surface deposit to which I particularly refer

was called Trail and Underplight by Spurrel.[1] It would appear that many of the disturbances which have been produced in drift and other deposits by the passage of ice over them are not of the same nature as those which occur in Underplight. Boulder-clays, for example, are often kneaded into the soft rocks upon which they rest, and thick deposits of sand and gravel have been disturbed greatly by ice which has passed over or been pressed into them. Disturbances of this nature have been described by Boswell[2] as occurring in the Suffolk Valleys. They affect Chalk, Thanet Beds, Reading Beds, London Clay, Crag, and glacial beds alike. In this area the trend of the summits and troughs of the folds, and other phenomena, indicate that the contorting force acted down the valleys, and the features noted are such as could not be produced by slip down the valley sides.

I have described and figured[3] the nature of the disturbances in the gravels, sands, etc., of the Trent Basin, which, from the strike of the ridges and troughs, show that they were due, like those described by Boswell, to forces acting down the main valleys. Such disturbances often present some of the features shown by Trail and Underplight, but, although this is the case, they do not appear to be of this nature.

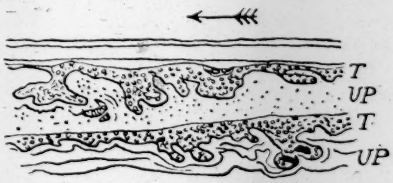

FIG. 1.—T, Trail; UP, Underplight.

Osmond Fisher[4] noted the surface feature we are considering very carefully; but was of opinion that the phenomena resulted from the infilling of drainage channels with rainwash and stones, combined with flow of the surface deposits. Such infilled channels certainly occur, and may be seen in the brickearth pits at Erith; but whether they are washouts produced by floods or prehistoric infilled game pits it is not always easy to make out.

In the paper already mentioned Spurrel deals with the question of the formation and nature of Trail and Underplight in some detail. According to him a typical section shows (1) vegetable soil, (2) rain warp, (3) Trail, and (4) Underplight. The vegetable soil is to a large extent the result of the activity of earth-worms as described by Charles Darwin. The rain warp, an unstratified more or less sandy clay with pebbles, varies in thickness from a few inches to several feet. The Trail generally consists of a more or less sandy clay with pebbles, and fills the troughs in the Underplight. The Underplight is the soft rock on which the Trail rests, and has been contorted so as to form irregular pits or troughs in which the Trail

[1] *A Sketch of the History of the Rivers and Denudation of West Kent, etc.*
[2] Q.J.G.S., vol. lxix, pp. 581–618, 1913.
[3] Ibid., vol. xlvi, pp. 437–79, 1886.
[4] Ibid., vol. xxii, pp. 553–65, 1866.

rests. The contorted nature of the Underplight is not of a character to suggest that the troughs are eroded hollows as Fisher supposed.

Fig. 1 is a copy of Spurrel's section xii, plate i. Here the surface flow is as shown by the arrow. There are two well-marked layers of Trail (T), the upper layer of Trail resting upon an Underplight of rainwash (UP), whilst the lower Trail rests upon an Underplight of brickearth (UP). The Trail has the appearance of being due to the sinking of beds of heavy clayey gravel and sand into lighter beds of sandy clay. Whilst this sinking of the upper bed was taking place the whole surface was flowing very slowly in the direction of the arrow, the upper surface moving farthest down the slope. Indeed, the phenomenon is one which we should expect to find in a fluid of high viscosity rather than in a plastic one such as clay.

It is very generally agreed that Trail and Underplight are not now forming in this country, and that although beds of heavy sand or gravel may be now at times spread over beds of lighter clay by surface floods, the plastic nature of the clay prevents the heavier gravel from sinking into it. However, if the clay were wet and were alternately frozen and thawed, then for a short time after each thaw the clay, brickearth, silt, loam, or soft chalk would be in a slightly fluid condition, and any beds of superior gravity which rested upon them would sink into the deposit below.

Although some regard a plastic substance as being a highly viscous liquid, technically it is not. A plastic substance is a solid which, if not overloaded, will carry a load put upon it for an indefinite period without yielding. A highly viscous liquid, however, yields slowly under any load, however small, and yields the more rapidly the greater the load (stress). Thus, if one stone be placed upon a piece of clay or soft plasticene, and another stone be placed upon a piece of hard brittle pitch, after an interval of a few months the one stone will be found resting as it was placed upon the clay or plasticene, whilst the other stone will have sunk more or less deeply into the brittle pitch. The pitch is a very stiff liquid and the clay is a soft solid. Under the conditions of climate now existing in this country the ground is seldom very deeply frozen, and consequently the soft beds of clay or brickearth are almost continuously in the plastic condition, and heavy material in or upon them cannot sink. But when the ground is annually deeply frozen and contains much moisture, for a short time after each thaw the thawed clay or brickearth virtually becomes a liquid for a time and allows heavier materials in or resting upon it to sink some distance.

It is clear that if the process of the sinking of a layer of gravel and sand into a lighter layer of soft clay went on long enough, the gravel and sand would eventually all collect beneath a layer of clay at the level to which the thaw penetrated each summer; indeed, some sections show beds of gravelly clay resting upon and covered by loam, clay, or brickearth, oblique streaks of small stones remaining in the upper deposit.

No doubt there is generally a slow bodily movement of hills composed of plastic clays, etc. Such movements, however, are not of the nature of fluid movement (viscous flow). They probably

result from the flexing of the whole crust, resulting from the tidal action of the moon and from undue stresses arising from denudation. In the construction of the Panama Canal movement of the beds took place to a large extent.

But would the settlement of a high gravity material into one of lower gravity produce results resembling Trail and Underplight? That such would be the case I have attempted to demonstrate in the following manner:—Into a shallow cardboard box a layer of pitch about 1 inch thick was poured. Upon this, when cold, a layer of sealing-wax mixed with fine and coarse sand was run. When the whole was quite cold the cardboard box was slung beneath an inverted incandescent gas burner. In this way the wax and pitch were slowly heated from above downwards and the viscosity reduced. Under these conditions the weighted wax slowly sank in irregular patches into the black pitch, which rose up around the descending wax. After the lapse of ten hours the cardboard box was removed and its contents allowed to cool, and when quite cool the cake of

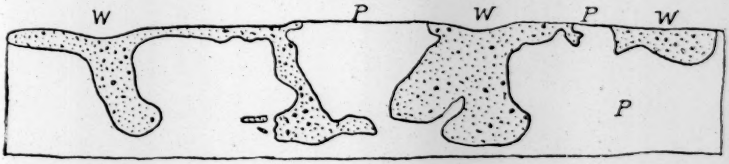

FIG. 2.—W, Wax; P, Pitch.

wax and pitch was broken through, Fig. 2 showing a trace along one of the lines of fracture. It will be seen that the forms assumed by the heavy wax closely resemble Trail, whilst the pitch assumes the form of Underplight. Close examination shows that the coarse grains of sand, especially near the sides of the descending masses of sealing-wax, stand in a vertical position as do the stones in Trail.

The above experiment does not, of course, prove that Trail and Underplight were actually formed in the manner assumed; but it does show that a bed of sand or gravel spread over a bed of soft clay, if rendered slightly fluid at times by repeated thawing, would most probably settle into a form which would resemble Trail and Underplight.

One of the points of interest is that deep freezing and thawing of the soil is required to produce the effect. We are dealing, therefore, not merely with conditions which are interesting as being a probable explanation of the method of the formation of Trail and Underplight, but with features which (in areas where soft clays occur and signs of true glaciations are absent) should enable us to ascertain when cold periods have occurred.

III.—Axinite Veins in the Penmaenmawr Porphyrite.

By H. C. Sargent, F.G.S.

In the course of a visit to North Wales last summer my friend Mr. Ivor E. Davies, of Penmaenmawr, called my attention to a mauve mineral, forming thin veins, in the intrusive porphyrite of

Penmaenmawr Mountain. The specimens containing the veins were not seen in place, but were collected from the waste-heaps of the Graig Lwyd Quarries, the most easterly of the large quarries that are making such deadly inroads into the heart of the mountain. Careful search on the waste-heaps enabled us to collect further specimens, and in some of these the mineral had built in fissures and cracks somewhat crowded, very sharp-edged crystals of tabular development.

I am indebted to the kindness of Dr. G. T. Prior, F.R.S., for the identification of the mineral in question as axinite. Several writers have made a special study of the Penmaenmawr veins,[1] but none of them seems to have been aware of the occurrence of axinite in them, and a brief description of its habit and associations may therefore be not without interest.

The vein-specimens collected vary in width from 2 inches downwards, but of this thickness the mauve axinite forms only an inner subsidiary vein, or veins, varying from half an inch down to a sixteenth in thickness. The other portion of the veins is of a light-grey colour, and is seen in thin sections to consist of axinite associated with a considerable proportion of quartz, the latter mostly in small irregular grains and clearly of secondary origin. The quartz sometimes takes on crystal contours on the edge of the light-grey portion of the veins and the crystals then penetrate the subsidiary mauve veins. The mauve infilling would therefore appear to be a later product than the light-grey axinite.

The thin sharp-edged crystals developed in fissures and cracks are of a pale-brown colour, and their greatest dimension is about a quarter of an inch. Sometimes the mineral forms thin radiating blades nearly an inch in length. Thin sections of the material in the veins do not show crystal outlines, the growth of crystals being interfered with by crowding, but cleavage is often well marked—on *m* (110) according to Weinschenk[2]—and extinctions measured to the cleavage-traces have a maximum angle of 42°. Sections which are inert, or nearly so, between crossed nicols are, of course, normal, or nearly so, to an optic axis. Such sections, in convergent light, show only one bar, which bends very slightly on rotation of the stage, thus indicating the wide axial angle ($2V = 72°$).[3] The dispersion is very marked ($\rho < v$).

Axinite, a borosilicate of lime and alumina, with variable amounts of iron, magnesia, manganese, etc., is generally associated with calcareous sediments and igneous rocks rich in lime, within the contact-aureoles of granites; but that it is of pneumatolytic origin, and not a product of thermo-metamorphism, has been shown by Messrs. Barrow & Thomas.[4] Its frequent association with prehnite,

[1] See, for instance, Waller, *Midland Naturalist*, 1885, p. 5; Teall, *British Petrography*, 1888, p. 275; Schaub, *Neues Jahrbuch für Mineralogie*, etc., Abh., pp. 108 et seq., 1905; Sargent, GEOL. MAG., Dec. VI, Vol. II, pp. 20–1, 1915.

[2] *Petrographic Methods*, trans. Clark, 1912, p. 366.

[3] Weinschenk, op. cit., p. 367.

[4] "On the occurrence of Metamorphic Minerals in Calcareous Rocks in the Bodmin and Camelford areas, Cornwall": Mineralogical Magazine, vol. xv, pp. 113–23, 1908.

as at Bourg d'Oisans, has been noted by other writers. Here, too, the mineral so abundant in the green veins of Penmaenmawr, which Schaub has determined as prehnite,[1] is at times seen to be intimately associated with the axinite. It has a lower refractive index and higher birefringence than the latter, and where cleavage-traces are developed it extinguishes parallel thereto (001). A genetic relationship between the two minerals appears to be indicated.

In all the cases which I have seen recorded hitherto the gaseous boron-bearing emanations leading to the production of axinite have followed the intrusion of a granite magma. At Penmaenmawr the magma was of intermediate calc-alkalic character. It is assumed that here, too, the hot gases charged with boron-compounds reacted on the original lime-bearing minerals of the veins, releasing the silica and forming new combinations with the lime and other constituents, and that thus the secondary mineralization of the axinite veins was essentially effected. In the Cornish greenstones the production of axinite is usually accompanied by "one or more of the following minerals, pyroxene, epidote, hornblende, garnet, quartz, and felspar, while zoisite, zincblende, sphene, and fluor-spar are sometimes present".[2] With the exception of quartz, a soda-lime felspar, and a little epidote, none of these minerals has been observed in the axinite veins of Penmaenmawr.

The green and other veins, which are so abundant at Penmaenmawr and have been previously described, as mentioned above, consist predominantly of micropegmatite and orthoclase, with subordinate plagioclase, augite, ilmenite, biotite, and apatite. It may perhaps be assumed that the axinite veins, which appear to be of very limited distribution, were originally filled with predominantly basic material, rich in lime; and that this took place at some other period, probably earlier in the course of the intrusive episode, than that which saw the production of the more acid veins. Somewhat confirmatory of this suggestion is the fact that in the same neighbourhood, viz. the most easterly Graig Lwyd Quarry, an interesting vein or patch was recently exposed, consisting essentially of calcite and talc, largely intergrown with each other.

IV.—The Permian Formation in the Alps of Piémont, Dauphiné, and Savoy.

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.R.S.E.

I. Introductory.

In a recent paper on the Marble District of the Apuan Alps or Carrara Mountains[3] I showed that the gneissose schists which form the nucleus of that range, and upon which rests the Triassic marmiferous formation, are, not of Archæan, but, upon irrefutable palæontological evidence, of Palæozoic age, and that, upon equally

[1] *Neues Jahrbuch für Mineralogie*, Abh., p. 110.

[2] *The Geology of the Country around Bodmin and St. Austell* (Mem. Geol. Surv.), 1909, p. 53.

[3] Geol. Mag., December, 1915, pp. 554–65.

conclusive lithological and stratigraphical evidence, they must be assigned to the later part of that period, that is, to the Lower Permian. The former conclusion was first arrived at in the course of the geological survey of the range by Lotti and Zaccagna and upon the palæontological authority of the late Professor Meneghini; the latter conclusion was chiefly the result of the striking analogy, first pointed out by Zaccagna, between the stratigraphical sequence and lithological characteristics of the Apuan Alps and the Montgioie range of the Maritime Alps which forms the divide between Southern Piémont and the Western Italian Riviera.

The geological survey of the Montgioie range, carried out in the 'eighties, was subsequently extended to a revisionary survey of the Italian side of the Cottian, Grajan, and Pennine Alps for the completion of the new geological map of Italy then in course of preparation and published in 1896; but the latter survey, by Zaccagna and Mattirolo, revealed such fundamental differences between the Italian interpretations and the existing maps of the French side of the Alps that it had, in its turn, to be extended to the French border districts.[1] In the result Zaccagna's conclusions, fortified by his experience in the Apuan and Maritime Alps, were fully confirmed, not only as regards the continuity of the Permian formation from the Maritime Alps to the Western Alps on the French side, but also in relation to the pre-Palæozoic formations, a great part of which was until then regarded by French geologists as of much more recent, that is, of later Mesozoic age.

Having visited the Piémontese, Dauphiné, and Savoy Alps on several occasions, both then and more recently, I propose to succinctly review the main features of the Permian formation in the principal localities, and also to refer briefly to some of the other important points elucidated by the Italian revisionary survey on the French side of the Alps. (See sketch-map, p. 10, and plan and sections, p. 11.)

II. The Permian in the Maritime Alps.

As shown in the sketch-plan (Fig. 1, p. 11), the Italian Maritime Alps, embracing the Ligurian and the Montgioie ranges, extend from Savona west to the River Tanaro, and thence to the Col di Tenda, beyond which lie the Mercantour gneiss and granite massif and the Cottian Alps. The Montgioie range, in which the Permian formation reaches its maximum development, comprises in a length of about 50 kilom. between the Tanaro—an affluent of the Po—and the Col di Tenda road a remarkable series of rugged and peaked mountains

[1] These surveys, accomplished in four consecutive short summer seasons, and embracing the Maritime and the whole of the Western Alps, including the Mont Blanc massif on both sides, constituted on Zaccagna's part a veritable *tour de force*, enhanced by his exhaustive reports in the Bollettino R. Com. Geol. d'Italia of 1887, pp. 346–417, and 1892, pp. 173–244 and 311–404, with maps and sections. He also compiled, with Issel and Mazzuoli, an excellent geological map 1 : 200,000 of the Ligurian and Maritime Alps for the Italian Alpine Club in 1887. The circular examination of the Mont Blanc massif was carried out by Zaccagna himself, while a section from the Arve (Chamounix) Valley across Mont Blanc by the Col du Géant to the Dora Baltea (Aosta) Valley was taken by Mattirolo.

of an average elevation of 8,000 feet, separated by passes up to 3,000 feet above sea-level. The highest mountain is Montgioie, 2,630 metres altitude, situated practically in the centre, but both on the north and the south the crest-range is flanked by a parallel range of somewhat lower elevation.

The Permian formation occupies, in a width of about 40 kilometres, the greater part of the central and also of the northern subsidiary range, the declivities of both being deeply eroded by the Tanaro and its tributary torrents. On the east the formation thins out towards the hills above Savona, and on the west crosses the Stura Valley, whence it passes into Dauphiné. The southern subsidiary range comprises Monte Abisso, Monte Rocchetta (2,473 metres altitude), and some deposits south of Col di Tenda, as part of the Permian formation, but is chiefly composed of Triassic and Liassic strata bordering on a large area of Eocene albarese limestone and macigno sandstone which reaches to the Riviera seaboard of San Remo. Besides Rocchetta and Montgioie, the most remarkable Permian mountain is Monte Besimauda, 2,404 metres altitude, which is entirely composed of that formation and with its double-peaked summit is a conspicuous object as part of the northern subsidiary range, being situated about 20 kilometres south of Cuneo and 10 kilometres east of the Col di Tenda road. The Permian formation, overlying the Carboniferous, may be conveniently studied in the outcrops of those and other mountains, more especially in the deep and narrow valleys of the upper Tanaro and its affluents, one of the most interesting and accessible of which is that of the Negrone torrent on the southern flanks of Montgioie, where the sequence of strata can be distinctly traced on both sides. Another instructive locality is that of the ravines of the Bormida torrents east of the Tanaro and south of Monte Settepani, where the contact of the Carboniferous and the Permian is well exposed at several points.

Up to the 'eighties the principal authority on the Maritime and Western Italian Alps was Gastaldi, who, besides his well-known studies on the crystalline and pietra verde rocks and an unpublished map of the latter Alps, left a memoir on the former.[1] He was at first disposed to class the gneissose schists of the Montgioie range with the Archæan gneiss of the Western Alps; but the Montgioie schists, owing alike to their "deficient crystallinity" and to their stratigraphical location, presented so puzzling a phenomenon that, pending further definition, he designated them as of indeterminate age under the name of 'apenninite', as being akin to the Apennines rather than to the Alps. As this formation does not extend east beyond the Savona hills, and is in no sense characteristic of the Apennines proper, the name was obviously a misnomer, and hence Zaccagna, who was the first to recognize its true stratigraphical position, chose the name of besimaudite, from Monte Besimauda already referred to, as typically representative of the gneissiform schist, which has its equivalent facies both in the Apuan and the Western Alps, and also in the so-called Suretta gneiss of the Splügen Pass.

[1] "Fossili Paleozoici Alpi Marittime": Atti R. Acad. Lincei, 1877.

Sketch Map of Permian Formation
from Maritime Alps to Montblanc. 1:2,000,000
0 20 40 60 Kil
Switzerland
Savoy
Isère
Arve
Dora Baltea
Po
Tanaro
Stura
Maira
Ubaye
Durance
Mediterranean
M. Blanc
M. Rosa
M. Cervin
G. Combin
G. St. Bernard
Pt. St. Bd
Courmayeur
Aosta
Ivrea
G. Paradiso
M. Iseran
M. Cenis
Modane (M. Cenis Tunnel)
M. Tabor
Billedonne
La Rousses
Ecrins
M. Chaberton
M. Genèvre
M. Pelvoux
Briançon
M. Viso
M. Chambeyron
M. Madallena
Cuneo
Savona
Mondovi
M. Argentera
Ormea
M. Pelat
M. Mercantour
Ventimiglia
Nice
N
W
E
S
altitudes in metres
Zones of Archæan Gneiss & Granite
Permian Formation.
Fronlier.
Del: D.R.P.

THE PERMIAN FORMATION IN THE MARITIME ALPS.

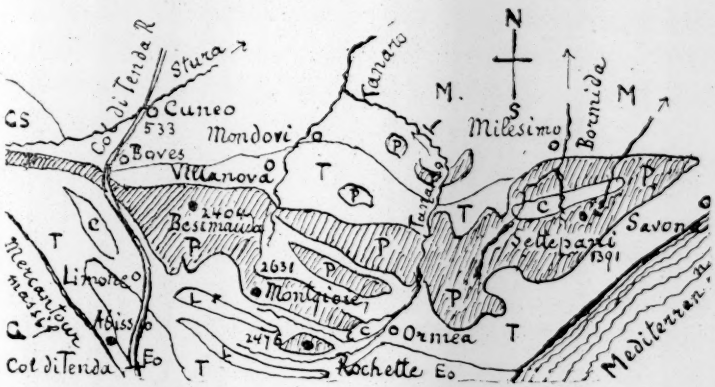

FIG. 1.—Sketch-plan. Scale 1 : 1,000,000.

M = Miocene.	P = Permian.
Eo = Eocene.	C = Carboniferous.
L = Lias.	CS = Calc-schist } Archæan.
T = Trias.	G = Gneiss }

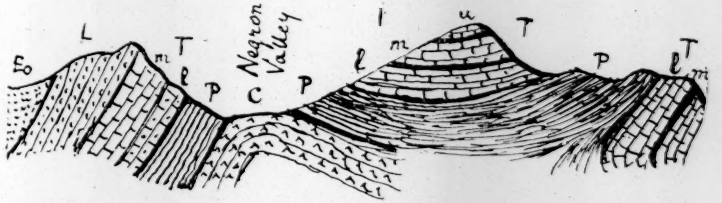

FIG. 2.—Section of Montgioie (2,631 m.), S. to N. Scale 1 : 1,000,000.
T, l, m, u = Lower, Middle, and Upper Trias.

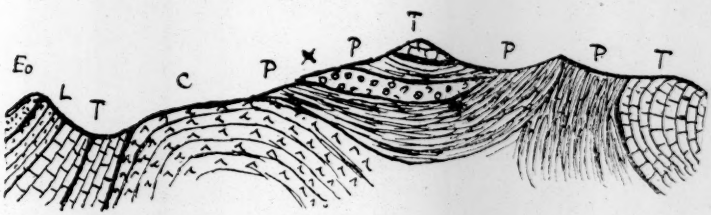

FIG. 3.—Section of Cime de Rochettee (2,476 m.), S. to N.
× = porphyritic mass.

D. R. P. del.

The Permian formation reaches a thickness of at least 1,000 metres, and rests directly and conformably upon the fossiliferous Carboniferous strata, which attain about half that visible depth and constitute the lowest zone of the Montgioie range. The latter strata are, as usual in the Alps, composed in the main of blackish carbonaceous and grey micaceous schists, graduating into talcose greenish calc-schists, which become felspathic and then pass into quartzose schist, which forms the base of the Permian formation. The Carboniferous age of the strata underlying the Permian, and consequently the Permian age of the besimaudite zone itself, was definitely established by fossils found in the Negrone Valley near Viozène, on the southern flank of Montgioie, by Zaccagna, and determined by Professor Portis of Pisa. Soon afterwards this discovery was confirmed independently by Squinabol and by Mazzuoli, both of whom found indubitably Upper Carboniferous fossils in the Bormida valleys already mentioned, where the Carboniferous strata are, moreover, anthracitic.[1]

The distinguishing feature of the besimaudite zone, like that of the equivalent schists of the Apuan Alps, is its gneissiform character, but it also comprises, in upward progression, a variety of associated rocks. Thus, from a granular quartzose schist it passes into greenish-grey compact rock of porphyritic texture with large elongated felspar crystals up to 2 centimetres in length. Again it passes into nodulous gneissiform schist without felspar, or again into sericitic schist, and in places also assumes a granitoid structure, notably above Savona. There are also hornblende-bearing intercalations, simulating the aspect of pietra verde. In Monte Rocchetta occurs a large mass of reddish porphyritic quartzose rock with white mica crystals, which Zaccagna regards as intrusive porphyry, and which also occurs in Monte Abisso, close to the Col di Tenda Pass; but I am disposed to regard both these masses, which, moreover, lie in a zone, rather as Upper Permian, very similar to the red verrucano or sernifite of the Glarus Alps, a clastic rock which often has all the appearance of porphyry.

The besimaudite zone is directly and conformably overlain by, and graduates into, a coarse conglomerate with white and reddish pebbles in a greenish, talcose matrix. This conglomerate or 'anagenite' is of considerable depth in the Montgioie range, and also occurs sparsely in the same position in the Apuan Alps. It represents the Upper Permian or Verrucano formation, and marks a transition from the latter to the Lower Trias. In my opinion, the porphyritic masses of Monte Rocchetta and Abisso already mentioned form part of it. It graduates, in its turn, into the conformably overlying Triassic series of quartzite, grey subcrystalline limestone, and calcareous schists, and these are overlain by banks of blackish, brecciform, marmiferous limestone with white calcite crystals, which is quarried near Villanova, at the northern base of the range, and is conspicuous in

[1] A. Portis, Boll. R. Com. Geol., vol. xviii, p. 417, 1887; L. Mazzuoli, ibid., p. 6; S. Squinabol, Giornale Scient. Genova, Fascic. Giugno, 1887. The survey of the Ligurian Alps eastward from the Montgioie range, surveyed by Zaccagna, was carried out concordantly by Mazzuoli and Issel, Boll. R. Com. Geol. 1884 et seq.

the columns and ornamental architecture of the churches and palaces of Turin. The Triassic series, about 400 metres in thickness, crowns Montgioie and most of the other principal mountains of the range, on the southern base of which occur also some Juraliassic and Cretaceous outcrops, followed by a large area of Eocene lime- and sandstone, while on the north it is bordered by an equally extensive area of Miocene marl and molasse.

Thus the stratigraphical sequence of the range, illustrated in the two typical parallel cross-sections of Montgioie and Rocchetta (p. 11, Figs. 2 and 3), exhibits a close analogy to that of the Apuan Alps from the Permian formation upwards. In the Montgioie range the flexures are inclined to the west, where the strata abut unconformably against the gneiss and granite massif of Mercantour; in both the Montgioie and the Apuan range there is considerable folding, but no faulting or unconformity, and their uniformity of age, sequence, and general lithological character is abundantly demonstrated.

III. The Permian in the Western Alps.

From the Montgioie range the Permian formation extends in a westerly direction to the Cottian Alps, and thence continues N. and N.N.E. to the Grajan Alps and the base of Mont Blanc. As the limits of this paper do not admit of a detailed description of the different localities, suffice it to indicate briefly the alignment of this extension of the Permian zone.

1. *In Dauphiné.* From near Boves at the north-western extremity of the Montgioie range, the Permian, skirting the Monte Viso massif on the right and that of Mercantour on the left, crosses the Stura Valley, and from here forms an uninterrupted zone about 60 kilometres in length and 2 to 5 kilometres wide to the Ubbaye Valley and Mont Chambeyron (3,388 metres altitude) on the Italo-French frontier. Thence it reappears further north on the south-eastern side of Briançon, near Mont Genèvre, and, skirting the frontier, continues for about 15 kilometres to Mont Chaberton (3,135 metres), this zone being about 2 kilometres in width.[1]

2. *In Savoy.* The next outcrop occurs about 20 kilometres north of the last point, near Modane, below the northern end of the Mont Cenis tunnel, in the Arc Valley, at an altitude of about 1,000 metres, whence it extends in a belt 5 kilometres in average width to St. Bon, Bozel, and Champagny in the Doron Valley east of Moutiers.[2]

[1] The Mont Genèvre group and Mont Chaberton have been dealt with at length in the interesting papers respectively by Cole and Gregory, Q.J.G.S., 1890, p. 305 et seq., and by Davies & Gregory, ibid. 1894, p. 307 et seq.

[2] Near Moutiers are the two geologically famous localities of Petit Cœur and Mont Jovet in the Tarantaise district of the Isère Valley. Near Petit Cœur, about 6 kilometres north of Moutiers, the long-debated phenomenon of a Carboniferous, fossiliferous stratum being wedged between two strata of Jurassic fossiliferous limestone was interpreted, among others by Lory, as due to a fault, whereas Zaccagna explained the Carboniferous strip more naturally as the remnant or denuded extremity of a synclinal fold, the other end of which appears in a somewhat larger outcrop at Hautecour, some 6 kilometres east of Moutiers. In Mont Jovet (2,303 metres), on the other hand, the puzzling feature was its being capped by a considerable mass of calc-schist with *pietra*

It then reappears—

3. *In Northern Piémont* above Courmayeur, at the foot of Mont Blanc, in the two well-known mountains Chétif and La Saxe (2,343 and 2,358 metres), separated by the Dora Baltea, and again, some 5 kilometres lower down the Dora Valley, in the Pian d'Arp, an eminence near Pré St. Didier.

Throughout this more or less continuous belt from the Maritime Alps to Mont Blanc the Permian exhibits the besimaudite and verrucano characteristics already described, and runs parallel with, and in normal sequence between, the Carboniferous and the Triassic series, so much so that the three zones, with the addition of a narrow Jurassic zone, all bifurcating at Col de Bonhomme, the south-western spur of Mount Blanc, form a belt, more or less interrupted by denudation, round that massif.

Of the Permian outcrops, those of Modane and Courmayeur are of special interest: (1) that of Modane, because Lory and other French geologists included it in their great zone of crystalline metamorphosed Triassic schists, whereas its interposition between Carboniferous and Triassic—both fossiliferous—strata clearly proves its Permian age; and (2) that of Courmayeur, because Chétif and La Saxe were regarded as granitic spurs of the Mont Blanc massif,[1] whereas Zaccagna recognized them as the northern extremity of a Permian synclinal fold, which is conformably overlain by the Triassic series, and whose southern extremity is the outcrop of Pian d'Arp near St. Didier, already mentioned. It appears again in the St. Mary Mountain near Aosta, some 20 kilometres down the Dora Valley.

In Savoy the Permian zone from the Arc Valley at Modane to the Doron Valley south-east of Moutiers has more recently been considerably enlarged by Termier, more especially in the Vanoise region and in the Doron Valley itself.[2] In Dauphiné the crystalline schists of Mont Genèvre near Briançon have also been assigned to the Permian, whereas this formation only skirts the western base of that group, and is overlain by dark, indubitably Triassic limestone corresponding to the grezzoni of the Apuan Alps, while the crystalline schists with their diabasic and serpentinous (pietra verde) intercalations are clearly Archæan.[3]

verde or *vert des Alpes* intercalations, surrounded by a Triassic belt. The former outcrop was regarded by Bertrand as Liassic, while Professor Lory included it in his Triassic metamorphosed *schistes lustrés*, and lastly, Zaccagna recognized it as *schistes lustrés* but of Archæan age, the *pietra verde* intercalations being conclusive evidence by analogy with Mont Genèvre, Susa, etc. Professor Gregory, in his searching analysis of all the evidence (Q.J.G.S., 1896, pp. 1–16), concludes in favour of the pre-Carboniferous age of the Mont Jovet schists, viz. in the absence of the Lower Palæozoic, virtually in favour of their Archæan age.

[1] The Val Veni depression between these two mountains and the granite massif of Mont Blanc is filled with Liassic limestone resting conformably against, the Permian of the former but unconformably against the latter.

[2] "Etude sur la constitution géologique du massif de la Vanoise": Bull. Carte géol. France, vol. ii, No. 20, 1891.

[3] A sketch-section of part of the Mont Genèvre group is given in Professor Bonney's paper, "Two Traverses of the Crystalline Rocks of the Alps": Q.J.G.S., 1889, p. 80. The limestone at the western end is marked Jurassic, probably on the strength of Lory's map as *Lias compacte* or *calcaire Briançonnais*. It is now included in the Trias.

IV. The Permian in relation to Archæan and Mesozoic Schists.

Intimately connected with the stratigraphical position of the Permian is the demarcation of the Archæan and Mesozoic schists. As is well known, both Elie de Beaumont in the French map (1860) and Sismonda in the Italian map (1862) of the Western Alps divided the crystalline rocks into two great zones—a lower one, comprising indiscriminately the Archæan gneiss, and the Palæozoic and Mesozoic series, as the "metamorphosed Jurassic area"; and an upper one, embracing the Archæan granite and all the pietra verde rocks, as intrusive and post-Jurassic. The later maps of Lory and Favre of the French, and of Gastaldi of the Italian side, to some extent disentangled that strange confusion: Lory and Favre by assigning the gneiss, granite, and the "vert des Alpes" to the Archæan and all the mica- and calc-schists indiscriminately to the Trias as "schistes lustrés", while Gastaldi separated all the pietra verde rocks into a zone *per se* as overlying the primitive gneiss and granite zone, and labelled it and the mica- and calc-schists as crystalline rocks, more recent, but pre-Palæozoic. The Permian did not figure in any of those maps.

Such was the position in the 'eighties when Zaccagna's revisionary survey showed those more or less arbitrary classifications to be obsolete and untenable. Accordingly he defined the Archæan as composed of two zones—a lower, comprising exclusively the primitive gneiss and granite rocks, and an upper, embracing the mica-schists (schistes lustrés) and the small-grained tabular gneiss; the calc-schists and crystalline limestone; and the great masses of pietra verde as a contemporaneous part.[1] From the Carboniferous formation, till then held to be the only representative of the Palæozoic in the Maritime and Western Alps, he separated the Permian besimaudite and verrucano zone directly overlain by the indubitably Triassic series in which he included Lory's "Lias compacte" or Briançonnais limestone. This clear definition of the Lower and Upper Archæan, the Upper Palæozoic, and the Lower Mesozoic formations harmonized the two sides of the Western Alps, and was embodied in the new geological map of Italy of 1896, a preliminary sketch of the earlier results in the Maritime and Cottian Alps having been already exhibited at the Berlin Geological Congress of 1885. These were largely, if with variations, adopted by Vasseur and Carez in their geological map of France of the same year.[2] Zaccagna's conclusions were thus, in the main, signally vindicated.

[1] The small-grained tabular gneiss (*gneiss minuto tabulare*) is extensively quarried in the Susa, Chisone, and Pellice Valleys for building purposes in Turin.

[2] Vasseur and Carez assign the crystalline schists west of Monte Viso on the Italian side to the Palæozoic (Cambrian), for which, however, there is no warrant, the absence of the Lower Palæozoic in the Western Alps being, on the contrary, an important feature as marking a long interval of erosion which led up to the Carboniferous formation, composed of the sedimentary and calcareous products of that erosion in which were engulfed the vast débris-accumulations of a luxuriant vegetation. The Archæan age of the crystalline schists was, after Zaccagna's publication in 1885, affirmed also by Professor Bonney (1886 and 1889), in relation to the Alps generally.

In so far as the degree of crystallinity, being the effect of metamorphism under pressure and high temperature, is a test of age, the Archæan highly crystalline schists differ from the gneissiform Permian schists as much as do the latter from the still less crystalline Triassic schists, e.g. those of the Apuan Alps as part of the marmiferous zone, albeit both those younger schists often simulate a gneissose aspect. As regards the Archæan schists, the presence of igneous rocks, whether primary or altered, is, of course, no absolute criterion of age, but in Piémont the enormous pietra verde masses of Monte Viso, of the Dora Riparia Valley, and of Val d'Aosta are by alternation, graduation, and lenticular intercalations, or again as irregular, obviously eruptive deposits, so closely associated with the mica- and calc-schists that their inclusion in the Upper Archæan zone appears perfectly legitimate. As in the younger schist-formations, so also in that Archæan zone the mica-schists always form the lower part of the zone, gradually passing into calc-schists which predominate in the upper part, with intercalations of saccharoidal limestone, quarried e.g. in the Susa Valley. It is with the upper parts of the mica- and the lower parts of the calc-schists that the pietra verde masses are more especially associated, and the intermediate position of the latter therefore points to their original subaqueous or superficial eruption in the corresponding period.[1]

V. Conclusion.

In the necessarily small sketch-plan (p. 11, Fig. 1) I have traced the Permian zone from the Ligurian Alps near Savona through Southern Piémont, Dauphiné, and Savoy to Mont Blanc, a distance of 250 kilometres. It is seen that the curved alignment of that zone, which would equally apply to the concomitant Carboniferous and Triassic zones, runs, in the main, between and parallel to the two great primitive gneiss and granite belts indicated by dotted lines, the outer belt comprising the Mont Blanc massif and the Pelvoux group in Dauphiné, while the inner, more continuous one extends from Monte Rosa to Gran Paradiso and Mercantour in Southern Piémont.[2] A third, smaller, but continuous inner belt may be said to lie between the Dora Riparia and the Maira Valleys, with Monte Viso midway

[1] In Piémont alone the crystalline schists, lying between the Mercantour massif in the south and Monte Rosa in the north, cover an area of 200 by 30 kilometres, or roughly 2,400 square miles, of which the three principal pietra verde masses represent about one-fifth. These masses are all composed of basic rocks, more especially of diorite, diabase, gabbro, serpentinous and hornblendic rocks. The white marble of Susa is, as shown above, Archæan, in contrast to the Triassic marble of the Apuan Alps, but both attest the process of the deposition of coarse calcareous material being followed by that of gradually finer to very fine material purified by solution and precipitation. The majestic triumphal arch at Susa shows that the marble of that locality, as that of Carrara, was quarried already by the Romans. Similar saccharoidal limestone intercalations are also worked in the Pellice, Upper Po, and Varaita Valleys. I propose to refer to these and the pietra verde areas, as also to Franchi's recent divergent views as to their age, in a subsequent paper.

[2] C. Diener outlines a similar series of belts in his *Gebirgsbau der Westalpen*, 1891, but embraces in his generalizations the entire chain of the Alps.

but outside the western edge, albeit this third belt forms more obviously part of the second one.

The surface-level of the Permian zone varies between 2,000 and 1,000 metres altitude, the highest being at Montgioie and Chétif (Courmayeur) and the lowest near Modane and in the Doron Valley, while the parallel Archæan zones vary in altitude between 4,000 and 3,000 metres. It is therefore obvious that the Permian and concomitant zones must have been deposited in a longitudinal trough at a time when the Archæan groups had already experienced a first partial raising, followed by a long period of erosion in the Lower Palæozoic interval. The marked unconformity at the points of contact between the Archæan and the Palæozoic and Mesozoic formations warrants the same inference of a long intervening period of erosion. A further uprise, which also affected the secondary formations, appears, on similar grounds of unconformable superposition, to have taken place in post-Liassic,[1] and a third occurred in Miocene times, which last-named movement, proceeding, like the preceding ones, mainly in a radial sense from the south-east, viz. from the Mediterranean, probably imparted to the Maritime and the Western Alps, as also to the Ligurian and Apuan ranges, their present general alignment and configuration.

The initial emergence of the Montgioie and Apuan ranges as ellipsoidal groups probably occurred before that of the Apennines; but it is during the third and last great movement that the final uprise of the Permian schists, already more or less subjected to metamorphism and overlain by the younger formations, must have taken place in the Apuan Alps as the nucleus of that range, and as its average surface-level of about 1,500 metres above the sea is the same as that of the analogous zone in the Maritime and Western Alps, it follows that the Permian formation in all the three ranges must have been raised to its present level simultaneously in Miocene times.

V.—A Chemical Examination of the St. Bees Sandstone of West Cumberland.

By Sidney Melmore.

THE following analyses were made to ascertain the magnitude of local variations in the St. Bees Sandstone of West Cumberland. It will be convenient for this purpose to consider the district as follows:—

The area south of St. Bees, as far as Calder Bridge.
The area north of Maryport, as far as Wigton.

1. The area south of St. Bees.

In view of its basin-shaped character, the observed dips in this area vary considerably in value and direction. On the whole, however, there is a constant dip to the south.

[1] Of this post-Liassic uprise, followed by a period of erosion, evidence is afforded by a general and marked discordance between the strata of the Upper Lias and the Tithonian, and, again, between the Neocomian and Senonian both in the Western and in the Apuan Alps.

The general character of the sandstone is so well known as to need no further description here. Under the microscope, specimens from this area exhibit a few cases of secondary deposition of silica on quartz. The average thickness of these secondary layers is about 0·02 mm.

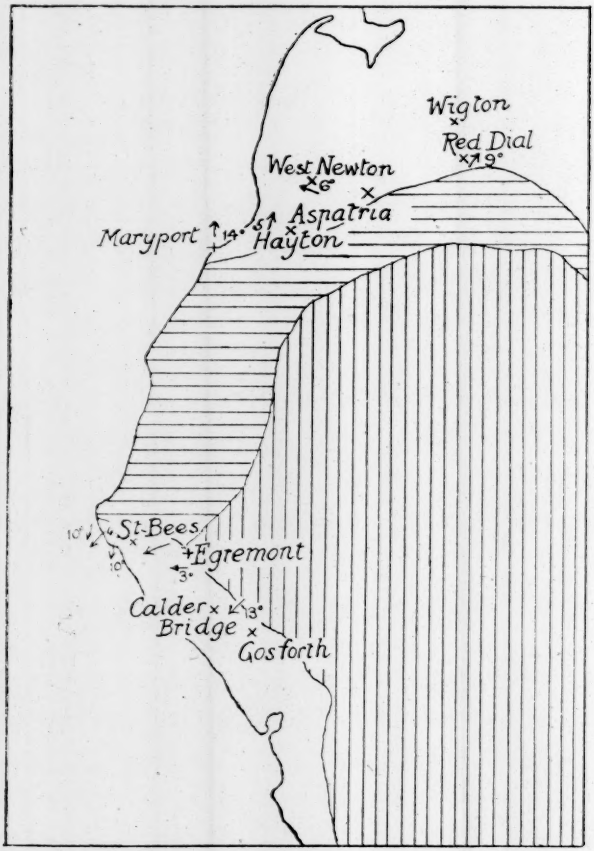

FIG. 1.—Map of West Cumberland, showing localities mentioned in the text, with the observed dips.

Samples of this sandstone were taken from St. Bees Head, a quarry near the village of St. Bees on the road to Egremont, a quarry near Whinscales, Egremont, and from a quarry at Calder Abbey, near Calder Bridge. Full analyses were made of the samples from St. Bees Head and Calder Abbey as representing the northern and southern portions of the area respectively.

The results are as follows:—

	I.	II.
SiO_2	83·99	85·96
Al_2O_3	8·37	6·93
Fe_2O_3	1·61	1·36
FeO	none	none
MnO_2	none	none
CaO	0·49	0·49
MgO	0·26	0·11
K_2O	3·412	2·844
Na_2O	1·253	0·70
CO_2	0·026	0·026
H_2O (combined)	1·11	0·723
Sulphuric acid (SO_3)	0·31	0·32
	100·831	99·463

I. St. Bees Head. II. Quarry at Calder Abbey.

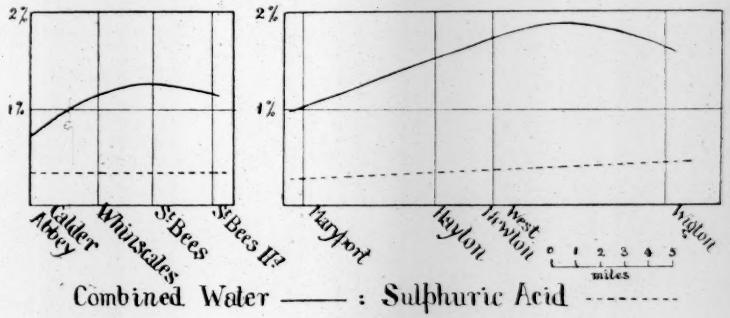

FIG. 2.

The amount of combined water in the samples from St. Bees Quarry and the quarry at Whinscales was also determined, as also the iron at the latter place. The percentage of combined water and sulphuric acid are stated graphically in Fig. 2, as by this means the variations are more easily seen. The amount of ferric oxide is fairly constant, but shows a slight increase towards the northern end of the basin. The total alkalis show a marked increase in this direction.

2. THE AREA NORTH OF MARYPORT.

The remarks on the tectonics of the southern area apply also to this northern basin, but the constant dip is to the north.

Samples were taken from quarries on the coast at Maryport, from a quarry at Hayton, from the West Newton Quarries, and from a quarry at Red Dial near Wigton. Fewer cases of secondary silica were noticed in the specimens from this basin, but when they occurred they were of the same order of magnitude as those in the southern basin.

The amount of combined water was determined in the samples from Hayton and Wigton. The value of the combined water at Maryport is somewhat less than that of St. Bees, but it rises steadily to a maximum near West Newton, and then begins to decrease.

Full analyses were made of the Maryport and West Newton samples; the results are :—

	III.	IV.
SiO_2	86·57	84·58
Al_2O_3	6·50	7·21
Fe_2O_3	1·92	2·05
FeO	none	none
MnO_2	none	none
CaO	0·57	1·40
MgO	0·083	0·098
K_2O	1·618	1·376
Na_2O	0·574	0·392
CO_2	0·078	none
H_2O (combined)	1·032	1·72
Sulphuric acid (SO_3)	0·285	0·345
	99·240	99·171

III. Sample from Maryport.
IV. Sample from West Newton Quarries.

The percentage of ferric oxide continues to increase from the value found at St. Bees till it also reaches a maximum near West Newton, and then decreases in value. The percentage of SO_3 rises slightly in a northerly direction, its amount, however, being practically the same for both basins. The total alkalis gradually decrease in the same direction.

Conclusions.

Considering each basin separately, all the localities where samples of sandstone were taken lie practically along the strike of the rock. The percentage of constituents found in these samples are therefore functions of the same geological horizon, and differ among themselves by virtue of their representing samples taken from different points of this horizon. The results therefore show superficial variations, rather than variations in geological time. It is well known that the process of kaolinization is accompanied by the formation of combined water, and this water is produced quantitatively in proportion to the kaolin. The degree of kaolinization can therefore be estimated with considerable accuracy by determining the amount of combined water in any sample of sandstone and correcting the value found for the presence of such other hydrated compounds as gypsum (Mackie, Trans. Edin. Geol. Soc., vol. vii, p. 454, 1899).

In the present connexion, the values of combined water plotted are uncorrected for combined water in $CaSO_4 . 2H_2O$, as the amount of calcium sulphate present in the sandstone is practically constant. Any alteration in the shape of the curve would be very slight if such a correction were applied. The substances whose presence is essential to kaolinization are water and carbon dioxide.

In sea-water the amount of dissolved oxygen varies from about 1 to 3 c.c. per litre, and the amount of carbon dioxide from 2 to nearly 40 c.c. per litre. The gaseous contents of sea-water increases with the depth to about 2,000 feet, below which depth the water contains scarcely any dissolved gases.

Assuming kaolinization to have proceeded under these conditions

below the surface of the sea, and to have given rise to the amount of combined water found in the different samples of sandstone, we can arrive at the comparative depth of the various points in the basin where analyses have been made.

A section through the St. Bees basin from Calder Abbey to St. Bees will thus show a maximum depth at a point almost midway between St. Bees and Whinscales, the depth decreasing north and south.

Similarly, in the northern basin the maximum depth is attained a little north of West Newton, and decreases more rapidly to the south than to the north. Thus both basins were steeper at their southern extremity than at their northern.

The depth of the basin at Maryport was not very great; in fact, we have evidence in the form of ripple-marks of littoral conditions at this place.

VI.—Brachiopod Morphology: Notes and Comments on Dr. J. Allan Thomson's Papers.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper, Manchester Museum.

FROM a long and careful study of the Brachiopoda I am led to offer some observations upon the two recently published papers by Dr. J. Allan Thomson which have appeared in this Magazine.[1] In the case of *Dallina* I cannot agree with Dr. Thomson regarding the type of folding. He considers *D. septigera* (the genotype) and *D. raphaelis* as dorsally biplicate, *D. floridana* as dorsally uniplicate. Now dorsal biplication is brought about by the dorsal sulcus being superimposed upon a single dorsal fold. In *D. septigera*, as well as in *D. floridana*, a broad ventral sulcus is superimposed upon a dominant ventral fold; these two species, therefore, are, in my opinion, ventrally biplicate (as in *Magellania flavescens* and some others).

This confusion of folding has led Thomson to question the generic position of *Terebratula grayi*, Dav., which was also referred to *Dallina* by Beecher.[2] This is a ventrally uniplicate species with alternate multicostation, and according to Thomson cannot belong to *Dallina*. He further states that "there seems to be no difficulty in referring it to *Magellania*, as it apparently possesses the Magellaniform hinge-plate and cardinal process". There is some mistake here; the hinge-plate is not Magellaniform. Davidson's figure[3] is misleading. There is no hinge-plate such as occurs in the genotype of *Magellania* (*M. flavescens*). A mesial septum is present, extending from about the middle of the dorsal valve to near the apex, where it merges with slight bifurcation into a thick deposit, on the floor of the valve. From each side of this deposit the dental sockets and crural bases arise; the cardinal process is transverse and weak. Apart from this

[1] "Brachiopod Morphology: Types of Folding in the Terebratulacea," Geol. Mag., Dec. VI, Vol. II, February, 1915, pp. 71–6; "The Genera of Recent and Tertiary Rhynchonellids," ibid., September, 1915, pp. 387–92.

[2] "Revision of the Families of the Loop-bearing Brachiopoda" and "The Development of *Terebratalia obsoleta*, Dall": Trans. Conn. Acad. Arts and Sci., ix, pp. 376–99, pls. i, ii, 1893.

[3] "A Monograph of Recent Brachiopoda": Trans. Linn. Soc. London; *Zoology* (2), iv, pl. x, fig. 3, 1886–8.

T. grayi cannot be referred to *Magellania*, or even to *Dallina*, on account of the ventral valve possessing dental plates in the form of strong buttresses with a small recess behind each. Dental plates are entirely absent from *Magellania* throughout life, and also from *Dallina septigera* and *D. floridana*, so far as the adult stages are concerned, but according to Fischer & Oehlert [1] the teeth of the ventral valve in *D. septigera* are supported in a young state by dental plates. These become attenuated with age and disappear entirely in the adult. *T. grayi*, therefore, is in need of a new generic name, as it cannot be referred to *Terebratalia* even, on account of the loop being in a higher stage of development. The name *Thomsonia*, therefore, is now proposed for this form.

Let us now turn to *Terebratalia*. This genus was founded by Beecher [2] on *Terebratula transversa*, G. B. Sowerby, a ventrally uniplicate shell, but, as Thomson points out, the actual species on which Beecher established a different ontogenetic series from that of *Terebratella* s.str. was *Terebratella obsoleta*, Dall.

Thomson considers this latter species to be a dorsally uniplicate form, and on this account creates a new genus—*Dallinella*—for its reception. Beecher's outline drawing of *T. obsoleta* [3] is very misleading, and gives a very erroneous idea of the type of folding. Dall's figure [4] is also of little service as it is only a dorsal view, but his description is very clear. I possess a specimen which agrees exactly with Dall's description, and shows the true folding to be undoubtedly ventrally biplicate. The anterior margin of the shell has much the same appearance as in some specimens of *Magellania flavescens*.[5] The teeth of the ventral valve are supported by dental plates which are rather more definite than in *Terebratalia transversa* and *Thomsonia grayi*.[6] In the dorsal valve the cardinalia is of the same weak character as in the two species just mentioned. The species, therefore, seems to me to be rightly placed in the genus *Terebratalia*.

Thomson further suggests that *T. transversa*, Sow., and *T. coreanica*, Adams & Reeve, are true *Terebratellæ*, and if so *Terebratalia* becomes a synonym of *Terebratella*.

T. coreanica agrees with *T. transversa* and *Thomsonia grayi* in having the same type of dental plates and weak cardinalia, except that the cardinal process is somewhat more definite. Like *Thomsonia grayi* there is a callous deposit in the umbonal area. This species and *T. transversa* cannot, therefore, be separated from the genus *Terebratalia*.

Such structural features as dental plates are, in my opinion, worthy of more consideration than has been given them in the identification and description of species. They are not only helpful

[1] *Exped. Scient. du "Travailleur" et du "Talisman"*, 1880–3, Brachiopodes, Paris, 1891.

[2] Op. cit., p. 382.

[3] Op. cit., pl. ii, figs. 6–9.

[4] Proc. U.S. Nat. Mus., xvii, pp. 726–7, pl. xxx, fig. 7, 1895.

[5] See Davidson, op. cit., pl. vii, figs. 6*b*, 10.

[6] The dental plates in both these are very similar, and appear to have been overlooked in descriptions of the species.

in defining genera, but their presence or absence is also an important character separating the two sub-families Magellaninæ and Dallininæ. They appear to be entirely absent from the Magellaninæ, but are always present in the true Dallininæ, even in fossil genera referred to this group.

The generic position of *Terebratula spitzbergensis*, Dav., is not easy to define. It possesses very definite dental plates which are more vertical than those in *Macandrevia*. The cardinalia, however, is not unlike that of *Dallina septigera* and *floridana*, i.e. typically Magellaniform.

With regard to *Terebratula frontalis*, Midd., this possesses somewhat obscure dental plates much as in *Terebratalia*. Its loop development and cardinalia suggest relationship with the Terebrataliform stage of *Macandrevia cranium* as figured by Beecher.[1]

Regarding the *Cincta*-like forms referred to *Laqueus*, the following notes, based on four of the species, may be of some interest:—

These species fall into two groups according to the character of the cardinalia. *Laqueus pictus* (Chem.) and *L. rubellus* (Sow.) possess obscure dental plates curving back to the apex of the valve. The hinge-plates in both are almost similar, consisting of two divergent buttresses rising from the floor of the valve and forming the dental sockets and crural bases. In *L. pictus* these buttresses are divided clear to the apex, where a small bilobed cardinal process is present. In *L. rubellus* there is no cardinal process, the divaricator muscles being attached directly to the apical parts of the buttresses. Each species possesses a slight mesial septum which in old specimens is superimposed on a broad and massive base with deep muscle imprints on each side.

L. californicus (Koch) and *B. blanfordi* (Dunker) have better defined dental plates, which are almost vertical in the latter. The dorsal valves of both possess Magellaniform hinge-plates (as in *M. flavescens*); there is no cardinal process. *L. blanfordi* is the nearest to *Cincta* in outward appearance, as the interior margin is strongly indented. None of my specimens of *L. californicus* show the ventral plication as given by Davidson,[2] but only a tendency towards a truncated front. Possibly Davidson's figure is incorrectly drawn.

The relationship of this *Cincta*-like group to the remainder of the Dallininæ is difficult to decide. The peculiar double attachment of the loop suggests a complete divergence from the general line of Macandrevian development. *Kingena* (type, *K. lima*, Defr.), a species also possessing dental plates, seems to be a possible Cretaceous representative of the *Laqueus* structure.

As to the Magellaninæ having representatives in northern oceans, this sub-family has a northern representative in *Mühlfeldtia truncata* (L.), an abundant species in the Mediterranean, and off the north of Spain, coast of France, etc.

Both the *Anomia truncata*, Linné, and the *Anomia sanguinea*, Chem.,

[1] "Revision," etc., pl. i, fig. G 1.
[2] Op. cit., pl. xviii, fig. 6*b*.

are given by Beecher[1] as belonging to the same genus, viz. *Mühlfeldtia*, but this is incorrect, as dental plates are entirely wanting in the former and are well-developed in the latter.

A. truncata was made the type of *Megerlia* by King in 1850,[2] but this name being preoccupied by a genus of Diptera in 1830, Bayle, in 1880,[3] established the genus *Mühlfeldtia* for its reception.

Dall, in 1870,[4] placed *sanguinea* in the genus *Ismenia*, King, but as this genus was founded by King on *Terebratula pectunculoides*, Schl.,[5] Dall, in 1895,[6] proposed *Frenulina* for the *A. sanguinea*, Chem.

Points of difference in the early stages of loop development, together with the presence of dental plates in one and their absence in another, seem good ground for the separation of these two forms into different sub-families, *Mühlfeldtia truncata* being placed in the Magellaninæ and *Frenulina sanguinea* remaining in the Dallininæ. The adoption of this course would necessitate the changing of the term Mühlfeldtiform stage in the Dallininæ to Frenuliniform stage.

One remarkable point of difference in the development of the loop in *M. truncata* is clearly seen in the figure given by Fischer & Oehlert[7] of an early stage of this species. Here the loop is strikingly like the early stage of *Terebratella dorsata*, figured by Beecher.[8] There appears to be no stage like this in the Dallininæ, where the descending branches of the loop appear early and are connected, thus forming a complete primary loop, whereas a feature of the Magellaninæ is the development of a secondary loop in the middle of the valve on the top of the septum, before the appearance of the primary lamellæ. Deslongchamps' figure[9] of a young example of *M. truncata*, 2 mm. in length, also shows a condition of loop somewhat similar to that of an adult *Megerlina lamarckiana* (another member of the Magellaninæ) figured by Beecher.[10] Some difference, however, is presented by the former having the ascending branches united to form a ring, whereas in *M. lamarckiana* the ring is incomplete.[11]

The loop of *Frenulina sanguinea*, on the other hand, passes through early stages exactly like those of *Macandrevia cranium*.

Rhynchonellids.

In describing the manner in which the delthyrium of *Hemithyris* becomes partially closed, Thomson[12] calls attention to a curious plate on the inner side of the apex of the pedicle valve. This plate, a kind of continuation of the deltidial plates, is free in front and separated from the shell by a narrow cavity. This feature, which I have termed the "pedicle collar" in my forthcoming report on the

[1] "Revision," etc., pp. 383–4.
[2] Mon. Perm. Foss. England (Pal. Soc.).
[3] Journ. de Conchyl., xxviii, p. 240, 1880.
[4] Amer. Journ. Conch., vi, p. 129, 1870.
[5] Not *T. pectunculus*, Schl.; see King, op. cit., p. 245.
[6] Op. cit., p. 724.
[7] Op. cit., pl. vii, fig. 11*a*.
[8] Op. cit., pl. i, fig. D*a*.
[9] Copied by Davidson, op. cit., p. 106, fig. 9.
[10] Op. cit., pl. i, fig. D*b*.
[11] See also Davidson, op. cit., pl. xxi, fig. 11.
[12] Op. cit., p. 390.

Brachiopods of the Terra Nova Expedition, is not by any means peculiar to the Rhynchonellids. It is present in *Liothyrina*, *Terebratulina*, and in all the short-looped forms I have been able to examine, some twenty-four recent species. It is also present in several fossil forms, including the large Crag fossil *Terebratula grandis*, *T. bisinuata* from the London Clay, and *Cyclothyris latissima* from the Lower Greensand of Farringdon. In *Terebratulina cancellata*, Koch, the pedicle collar is strongly developed, and forms a perfect tube extending forward for some little distance, whilst in *Megathyris decollata*, Chem., it is well-developed and is supported by a sharp mesial septum. It is a structure which grows larger as the shell increases in size, and is the "doublure sous-apicale" and "doublure sous-cardinale" of Fischer & Oehlert.[1]

Judging from my own collection the pedicle collar is never developed in the higher long-looped forms; it is entirely absent from the following genera: *Magellania*, *Terebratella*, *Dallina*, *Macandrevia*, *Terebratalia*, *Laqueus*, and *Frenulina* (type *sanguinea*). In some of these, however, there is occasionally a thickening in the umbo around the foramen assimilating a pedicle collar, but it is fused to the shell and never free anteriorly.[2]

In the lower genera referred to the family Terebratellidæ a curious feature is present: *Mühlfeldtia truncata* and *Megerlina lamarckiana* both possess a pedicle collar, but *Kraussina rubra* does not; it only has a thickened plate fused to the floor of the umbonal cavity.

Genus Ætheia, Thomson.

With regard to the relation of *Rhynchonella lucida*, Gould, to Thomson's new genus *Ætheia*, I possess a specimen of this form and find that it possesses fairly strong dental plates. This fact, together with the hypothyrid character of the pedicle passage, excludes the species from *Ætheia*. Like *Hemithyris psittacea* there is no true cardinal process in the dorsal valve, the divaricator muscles being attached to the posterior ends of the crural bases.

The absence or presence of a cardinal process in Rhynchonellids seems to be a matter upon which some difference of opinion exists. In *H. psittacea* I have failed to find any structure analogous to a true cardinal process, but in two large adult specimens of '*Hemithyris*' *nigricans* in my collection from Chatham Islands there is a small but distinct transverse bilobed cardinal process extending outwards like a shelf from the apex of the valve; the mesial septum in these specimens is also much stronger than in *H. psittacea*. In the ventral valve the dental plates are recurved towards the apex and not vertical as in *H. psittacea*.

Regarding dental plates, etc., a close study of the fossil forms of the *nigricans* group would no doubt reveal some interesting features. The Manchester Museum possesses three specimens belonging to this group from the Table Cape Beds at Wynyard, Tasmania. One of these specimens is apparently closely related to *H. nigricans*; the

[1] *Expéd. Scient.*, pp. 44, 103, etc.

[2] In old adult shells of *Hemithyris psittacea* the pedicle collar sometimes becomes fused to the floor of the umbonal cavity of the ventral valve.

surface of the valves is ornamented with about thirty ribs, which are rather more angular and squamose than in typical *nigricans*; a mesial septum is also visible through the shell of the dorsal valve. Without spoiling the specimen it would be impossible to study the internal characters.

The two other specimens, one broken, the other perfect, are quite distinct from that described. The valves are ornamented by about forty-six radiating costæ, increasing by bifurcation. The costæ are divided by moderately deep furrows and are surmounted by short tubular spines which are arranged concentrically, following the growth-lines. The dimensions of the perfect specimen are as follows: length 16·5 mm., breadth 19 mm., depth 7·5 mm. The imperfect example represents a shell of approximately the same size, and is interesting as it exhibits the internal characters. The teeth of the ventral valve are supported by very distinct dental plates, which differ entirely from those of *H. nigricans* by being almost vertical and more like those of *H. psittacea*. The foramen is rather large and the pedicle collar somewhat weak, as are also the deltidial plates. The dorsal valve possesses a thin mesial septum extending to the apex, while the dental sockets and crural bases are more divergent than in *H. nigricans* and *psittacea*. No cardinal process is visible.

I am unable to identify the above species with accuracy owing to the absence of specimens for comparison, but it seems to be related to *Rhynchonella squamosa*, Hutton = *cælata* (M'Coy MS.), Woods = *pyxidata* (Watson MS.), Davidson.

Hemithyris imbricata, Buckman,[1] from the Miocene–Oligocene beds of Cockburn Island, off Graham Land, Antarctica, is near to it in general appearance, but this species appears to possess no dental plates.

Another species possessing some resemblance to the one under discussion is *Rhynchonella* (?) *tubulifera*, Tate,[2] from the Oligocene of Muddy Creek, Victoria.

VII.—Glacier Lake Channels.

By Percy Fry Kendall.

IN 1902 I published a paper,[3] the outcome of several years' observation, on certain phenomena associated with the glacial deposits of the Cleveland area, which I attributed to the former presence of a series of temporary lakes and lakelets upheld in the recesses of the hills by the margin of a great ice-sheet occupying the greater part of the North Sea. This interpretation met with so wide an acceptance, even by those geologists familiar with the district who had previously attributed the glacial deposits to a marine origin, that during the succeeding thirteen years I have steadfastly refrained from replying to criticism, hoping by this abstention to keep the issues unclouded by a controversy that might at any stage develop an acerbity not always lacking in earlier discussions.

[1] "Antarctic Fossil Brachiopoda, etc.": Wiss. Ergebn. Schwed. S.P. Exped., 1901–3, Bd. iii, No. 7, 1910.

[2] Trans. Roy. Soc. S. Australia, xxiii, p. 257, 1899.

[3] Q.J.G.S., vol. lviii, pp. 471–571.

Professor Bonney has favoured me with a copy of a pamphlet[1] in which he subjects my views to a criticism based upon a careful examination of parts of the area. Not content with mere destructive criticism, he elaborates in some detail an alternative explanation. The whole paper is so moderate, and the author's appreciation of my work so generous, that I must break through my self-imposed rule of silence, and this I do the more willingly as no other critic has ventured to suggest any other hypothesis.

I may briefly recite the phenomena to be explained. A great series of sharply-cut ravines, in some cases veritable gorges, traverses the country, either within the area occupied by glacial deposits or just beyond its margin. Their transverse section closely resembles that of a railway cutting, with which Professor Bonney aptly compares them; there is the steep 'batter', the flat floor, and, let it be particularly noted, a comparable sharpness in the angles at the top and bottom of the slope. Sinuous channels have a steep batter on the outsides of bends, and gentler slope on the inside curve, just as we find in the case of the *banks* of a river, though not commonly of a river *valley*. I draw two inferences from these features: (1) that the channels were excavated rapidly by a volume of water sufficient to occupy the whole floor, (2) that their formation was so recent that denudation has done little to modify the original contours.

As regards situation, they are found cutting through watersheds, even the main water-parting of the whole district (e.g. Newtondale), and sometimes trenching boldly projecting spurs. Often a succession of spurs are cut along a line, as though an originally continuous channel had been segmented up by the development of cross-contour valleys of normal type. A feature which opposes this interpretation is that, instead of the fall-line constituting a continuous gradient from end to end of the series, the outfall level of one segment generally coincides with the intake-level of the next, even though a distance of a mile or two may intervene. This arrangement is explicable on the supposition that the intervening space was occupied by the standing waters of a lake, but is difficult to reconcile with an original continuity of the channels. Similar relations have been observed in many parts of Scotland and of the North of England.

Another significant arrangement is that which I have called a "Parallel Sequence", that is, a series of parallel channels cutting at successively lower levels a single spur. They fall in the same direction, and there is a method indicated by their relative heights; each channel, as a rule, commences to break the ridge-line of the spur at almost the exact level of the intake of the next higher channel, as though—this is my explanation—the channels drained a lake held up by an ice-barrier, and when the ice withdrew so as to uncover a slope below the intake level, the drainage was diverted and the formation of a new channel begun. In some cases six, eight, or even more channels traverse the same spur in a distance of a mile or two. No comparable case of river-capture is known to me, and I am unable to imagine conditions which would produce such an effect. The

[1] *On certain Channels attributed to overflow streams from ice-dammed lakes.*

systematic disposition of the channels is still more comprehensively exhibited when a larger area is embraced in the review. The Cleveland area illustrates this fact with admirable clearness, for which reason I entitled my description "A System of Glacier-lakes in the Cleveland Hills".

On the northern face of the hills I found evidence of a series of lakes draining, some to the westward of a dividing-line by a set of lake-to-lake channels into a lake in upper Eskdale; another set draining eastward to a main overflow by which they discharged into the same lake. The lake in Eskdale was, I supposed, upheld by a lobe of ice that stood across the Esk, leaving a mass of boulder-clay near Lealholm as a species of moraine. I may remark in passing that, as Professor Bonney no doubt observed when he visited the place, this supposed moraine divides the Esk Valley into two parts of surprisingly different topography, the upper part characterized by enormous terraces of ancient (lake-)alluvium, and the absence of any boulder-clay hills or other characteristic glacial features, as well as of gorges along the course of the river; while, below this obstruction, the tumultuous heaps of boulder-clay and other Drift deposits, and the succession of gorges through which the river passes form a contrast as complete as could be desired to the tamer river-scenery of the higher reaches.

The ice-lobe similarly obstructed the tributary valleys on the south side of Eskdale, and not only are there masses of boulder-clay obstructing their lower ends and producing topographic contrasts comparable with those of the main valley, but the spurs are trenched by channels by which the lake-waters evaded the obstacles. To complete the series these channels conducted to a lakelet near Goathland, and thence across the main Cleveland watershed by the giant trench of Newtondale into the Vale of Pickering.

Space does not permit me to discuss in full detail the whole system, and it would be hardly fair to my courteous critic to evade the issues specifically raised by him. I will therefore confine my attention to one district of which his knowledge is almost as recent and probably as full as my own, viz. the country between Fen Bogs, near Goathland, and the Esk Valley at Egton Bridge. The interested reader will find it fully pourtrayed in the map with 25 ft. contours in my paper already referred to (pl. xxii), or, better still, in the Proc. Yorks Geol. Soc., 1903, pl. vi.

The general build of the country is fairly simple—the axis of the main Cleveland anticline runs W.-E., about through Julian Park. The River Esk flows along an inflection of the northern slope of this fold. The Murk Esk, a tributary of the Esk, rises by two heads, Eller Beck and Wheeldale Gill, from the *south* side of the anticline, and these streams, after flowing for distances of one and two miles respectively towards the south, recoil from an opposing escarpment and swing round across the anticline—a very clear case of 'stream trespass', as Fox Strangways showed.

The 'certain channels' in this area are—(1) Two parallel trenches on Murk Mire Moor, beginning as open notches on the bold scarp overlooking the Esk Valley within a mile or a mile and a half of the

river, and respectively 450 and 600 feet above its level. They cut across a prominent spur and then coast along it for two or three miles, and finish almost as inconsequently as they began. (2) A headland, Two Howes Rigg, separating Wheeldale Gill from Eller Beck, is trenched by a channel about a mile long that carries on the chain to within about a mile of the beginning of Newtondale, a tremendous ravine that attains a depth of 250 feet where it passes through the escarpment formed by the Kellaways Rock.

Professor Bonney regards these 'channels' as relics of a very ancient river system that has been encroached upon by a more energetic system, namely, that of the Murk Esk. In my first attempts to elucidate the river development of the Cleveland area I attributed the principal rôle to river-capture, and presented it for discussion at a meeting of the Yorkshire Geological Society, but later, when I descended to details, I found insuperable difficulties, and I think Professor Bonney will recognize their importance. Firstly, the lower channel on Murk Mire Moor—as I have mentioned, begins with a perfect railway cutting section within one mile of the River Esk and 450 feet above it. The floor falls, not towards the river, but away from it, with a fairly steady gradient except for accumulations of peat and a small amount of running down of the sides. The upper channel falls in the same direction, and the channel on Two Howes Rigg continues the course, but from west to east. After a short interval the great gorge of Newtondale, falling south, completes this series. I ask, is it likely that two rivers could have flowed backward across the Cleveland anticline and away from the Esk, the main drainage line of the district?

Their sections, as I have pointed out, indicate that they carried a large volume of water. Whence was it flowing? Several alternatives might be suggested—(1) That the channel had been deprived of its headwaters by the widening of the Esk Valley. This, unless the course of the Esk has been materially altered, would increase the drainage by one mile, and then only on the assumption of a vertical side to the Esk Valley. (2) That the Esk itself flowed this way and cut the Newtondale channel as well as those along the Moor-edge. Such a readjustment of drainage is not only opposed to the whole build of the country, but it seems negatived by the behaviour of Wheeldale Beck and Eller Beck, which shows that the 'trespass' was all in the opposite direction (i.e. encroachment across the anticline by the Esk by virtue of the 'law of steepest slope'). (3) That there was no Esk Valley at the time when these channels were operative and that the drainage of the North Cleveland hills, ignoring syncline and anticline alike, came over into this system. I do not think such a hypothesis needs any refutation, for Professor Bonney expresses the opinion that the original watershed was "rather more than a quarter of a mile north of Goathland Station". This is almost exactly on the axis of the anticline. A watershed in such a position would, however, attach the Murk Mire Moor channels to the Esk drainage, although they slope directly away from it.

(To be continued.)

NOTICES OF MEMOIRS.

I.—The Ordovician Sequence in the Cader Idris District (Merioneth).[1] By Arthur Hubert Cox, M.Sc., Ph.D., F.G.S., and Alfred Kingsley Wells.

REFERENCE was made to the work of previous observers, including Sedgwick, Ramsay, Cole and Jennings, Geikie, and Lake and Reynolds.

The Cader Idris range is formed by a great escarpment of Ordovician igneous rocks, facing northwards across Barmouth Estuary towards the Harlech dome. The igneous rocks were for long regarded as being all of Arenig age.

Re-examination of the area has shown the presence of four distinct volcanic series among the Ordovician rocks, and the following descending sequence has been established—

Glenkiln-Hartfell	10. Talyllyn Mudstones	Grey blue-banded mudstones with *Amplexograptus arctus* in the lowest beds	800 ft.
Glenkiln with Upper Llanvirn	9. Upper Acid or Craig-y-Llam Series	'Andesitic' and rhyolitic ashes and lavas	900–1,000 ft.
	8. Llyn Cau Mudstones		500 ft.
	7. Upper Basic or Pen-y-Gader Series	Pillow lavas (spilites) with tuff and chert bands	300 ft.
	6. Llyn-y-Gader Mudstones and Ashes	Blue-grey mudstones with thin adinole-like bands and with massive ashes above and below	450 ft.
	5. Dark Mudstones	Frequently containing pisolitic iron-ore	80 ft.
	4. Lower Basic or Llyn Gafr Series	Pillowy spilitic lavas with intercalated ashy and shaly bands, massive banded and agglomeratic ashes at the base	1,500 ft.
Lower Llanvirn	3. Didymograptus bifidus Beds	Dark slates with well-marked ash bands in the lower portion	500 ft.
Arenig	2. Lower Acid or Mynydd Gader Series	Rhyolitic ashes with some slates above, rhyolitic lavas below	300 ft.
	1. Basement Beds	Striped arenaceous flags and grits	100 ft.
	Unconformity		
Upper Cambrian	Tremadoc Beds		

Both acid and basic rocks occur as sills at numerous horizons. The basic rocks are diabases of various types, all with the felspars considerably albitized and usually with primary quartz. The acid rocks are soda-granophyres. The granophyre intrusions cut and are later than the basic intrusions, and locally hybrid rocks appear to have been formed along the junctions. No basic intrusions have been found above the Upper Basic Volcanic Series, and no acid intrusions above the Upper Acid Series, and it is noteworthy that the

[1] Read before the British Association, Section C, Manchester, 1915.

granophyres appear to be closely related to the extrusive rhyolites among which they are intruded. This fixes an upper limit to the age of the diabases in this district.

The various beds strike more or less east to west, and dip steadily southwards at about 40° until the Talyllyn Mudstones are reached, when folding and rolling of the beds immediately begin. Two N.E.–S.W. shatter faults—the Dolgelley and Talyllyn faults—cause a certain amount of repetition, and give rise to the Dolgelley-Llyn Gwernon and to the Talyllyn Valleys, the former to the north and the latter to the south of the escarpment. A strike-fault between Mynydd Gader and Cader Idris cuts out the whole of the Bifidus Beds, bringing the Lower Acid and the Lower Basic Volcanic Series against one another. The intrusive rocks frequently cause local variations in the dip and strike.

All the softer strata are strongly cleaved, so that fossils are difficult to obtain. The slates within the Lower Acid Series have yielded a few extensiform graptolites, while from the Bifidus Beds the characteristic fossils were obtained at numerous localities. The *D. murchisoni* zone has not been recognized by the authors, its place presumably being occupied by a part of the Lower Basic Series. The dark mudstones among which the pisolitic iron-ore is developed have yielded rather obscure graptolites, which, however, indicate a fairly high horizon in the Llandeilo Series. The presence of *Amplexograptus arctus* and *Glyptograptus teretiusculus* var. *euglyphus* in the lowest beds of the Talyllyn Mudstones indicates a high horizon in the Glenkiln, or, in other words, a low horizon in the Caradocian, and suggests that the immediately underlying Upper Acid Series is at approximately the same horizon as the Snowdonian volcanic rocks of Conway. This youngest of the four volcanic series on Cader Idris is therefore considerably higher in the Ordovician than has been previously supposed. The position of the boundary between Caradocian and Llandeilian has not yet been established, owing to the unfossiliferous character of the blue-grey mudstones of Llyn-y-Gader and Llyn-Cau.

One of the authors (A. H. Cox) is indebted to the Government Grant Committee of the Royal Society for a grant which has partially defrayed the expenses involved in the investigation. The area is being mapped on the 6 inch scale.

II.—The Corrosive Action of certain Brines in Manitoba.[1] By Professor R. C. Wallace, M.A., Ph.D., B.Sc.

BRINE springs issue from Middle and Upper Devonian limestones and dolomites at the foot of the Manitoba escarpment. At least eighty brine areas are known, with a total flow—during the dry season—of approximately 500 gallons per minute. The water circulates in the Dakota Sandstone, the basal member of the Cretaceous series, and extends laterally into the Devonian calciferous formation, from which it leaches sodium chloride, disseminated through certain dolomite horizons. The composition of the brines,

[1] Read before the British Association, Section C, Manchester, 1915.

expressed in percentages of total solids, is very similar to that of sea-water. It is a somewhat purer solution of sodium chloride, and also a more concentrated solution, than sea-water, the percentage salinity being 5–7 (sea-water 3·5).

The salt-flats where the springs reach the surface are devoid of vegetation and studded with ice-carried boulders. These are representative of the pre-Cambrian igneous series of North-Central Canada—granites, gneisses, and epidiorites. They have suffered intense chemical disintegration, large boulders having been reduced to half their original size. Different minerals have been affected to different extents, but not even quartz or garnet has escaped corrosion. Ferromagnesians have been most intensely affected; and gneissose structures, hardly noticeable on unweathered surfaces, stand clearly revealed. The striking difference between the action of these brines and that of sea-water calls for explanation.

Thin crusts of salt gather, during the summer months, on the flats and around the boulders. The salt is somewhat deliquescent; and thin films of brine are drawn, by surface tension, over the surface of the boulders. Water in contact with the atmosphere is a powerful disintegrant. Alkalies are removed as chlorides or carbonates, and silica and alumina are precipitated as gels, separately or in combination. The gels exercise selective adsorption on the salts of the brine, alkali being taken up and the brine being left richer in the acid radicals. The brine is thereby rendered a more active disintegrating agent, and the process goes on continuously. The function of the dissolved salts is considered to be twofold: (1) they provide a thin film of liquid in contact with atmospheric oxygen; (2) owing to partial adsorption by colloids, they provide an acid residual solution, which is a powerful corrosive agent.

The evidences of the corrosive action of sea-water on beach boulders are no doubt obscured by mechanical attrition due to wave action. Such corrosion cannot, however, be compared in intensity with that of the brines. Boulders between high- and low-water mark are alternately submerged and dry to the base—a state of affairs inimical to the persistence of thin films of liquid on the surface of the boulders. The initial conditions are consequently wanting; and the relative immunity of beach boulders from chemical corrosion is due, not to any inability of sea-water to act as a corrosive, but to the absence of favourable conditions for the activity of the solution.

REVIEWS.

I.—The Antiquity of Man. By Arthur Keith, M.D., F.R.S. pp. 519, with 189 text-figures. London: Williams & Norgate, 1915. Price 10*s.* 6*d.* net.

THE subject of the antiquity of man seems naturally to fall to the geologist, with such aid as he can obtain from the human anatomist and archæologist. The value of the evidence which has to be considered can only be estimated by one who has a practical acquaintance with geological problems in the field. From Lyell onwards, therefore, all the most important works dealing with the

question have been written by geologists; and he is indeed a bold man who would form independent judgments on the materials taken at second hand. Now, however, a distinguished human anatomist has entered the field, discussing the antiquity of man from his own point of view and trusting to such quotations from geological literature as suit his purpose. We therefore turn with great interest to Professor Arthur Keith's handsome volume which has just been received.

Professor Keith writes in an attractive style, and though at times his matter is somewhat technical his explanatory figures are so numerous and clear, placed as they are in frames of standard magnitude, that even the non-anatomical reader will find no difficulty in appreciating his points. His story, indeed, is that of an eager student ever searching for the meaning of things, and it gives an excellent idea of the aims and methods of modern physical anthropology. Our only regret is that lack of a geologist's caution permits him to make dogmatic statements about the age of the various remains in terms of years, which will doubtless give gratifying satisfaction to an unwary public, but will also deceive them in an unfortunate manner.

Professor Keith begins with Neolithic man, and shows that he differs in no respects from the men of Europe at the present day. His description of the discovery of his remains in the megalithic monument at Coldrum, Kent, is a good example of his picturesque writing. We hardly appreciate the comparison of this monument, however, with the Sardinian 'giant's tomb', when the relative proportions and positions of the stones have to be so much altered to make it plausible (cf. figs. 3 and 9).

Proceeding to Palæolithic man, Professor Keith shows, from the well-authenticated cases of Paviland, Engis, and Cro-Magnon, that at least the later races were also similar to those of modern civilized man. He then soon begins to illustrate the disadvantage of his position by accepting as valid evidence a series of human remains, of which scarcely any—perhaps none—can be regarded with certainty as belonging to the age of the stratum in which they occurred. He even continues to believe that the Galley Hill man dates back to the Chellean period, and thinks that the Ipswich man may be earlier. Thus he assigns a much greater antiquity to modern man than a cautious geologist or palæontologist would be disposed to do. In fact, he introduces unnecessarily an anomaly into the series of undoubted fossil human remains which accord with palæontological theory and expectation.

Of these undoubted fossil remains Professor Keith gives an excellent account, enlivened by his own observations, and treats in succession of Neanderthal man, Heidelberg man, *Pithecanthropus*, and *Eoanthropus*. The discussion of the latter genus, or Piltdown man, is especially interesting, and occupies no less than 200 pages. The precise result is a little obscure, but Professor Keith now admits that the chimpanzee-like lower jaw was correctly restored by the palæontologist, and he has considerably reduced his original estimate of the size of the brain-case, which he thinks cannot have exceeded 1,400 c.c. We can only express the hope that Mr. Charles Dawson will continue his

researches in the Piltdown gravel, and discover more nearly complete specimens which may solve some of the problems that still remain inexplicable.

II.—Prehistoric Archæology.[1]

IN the first paper in the list Professor McKenny Hughes deals with flint, its origin and destruction, and the extent to which chipped flints are reliable evidence of the presence of man. The paper is founded mainly on the series of specimens brought together in the Sedgwick Museum at Cambridge. The following paragraph deserves serious consideration nowadays: "Let us now take a few groups of naturally shaped flints. First there are those which are called 'Figure Forms'. M. Boucher de Perthes was the first to call serious attention to them. He was the man who in 1857 announced the discovery of palæolithic implements in the valley of the Somme; and it is often said in reply to those who criticise adversely the evidence upon which a more remote antiquity is now claimed for man than had been previously supposed, that the same thing was done in the case of Boucher de Perthes' discoveries. But the rejoinder is obvious. Had Boucher de Perthes not supported a correct theory by bad evidence the acceptance of his views would not have been so long retarded. We cannot in science give a bill of indemnity for false reasoning, though it was in support of a suggestion which afterwards turned out to be true."

Dr. Holst in the second paper gives a short and very clear account of the prehistoric flint-mines near Malmö in Southern Sweden. These pits are sunk in gigantic erratic blocks of chalk, the largest being about 3000 × 1500 × 10–20 feet.

Though necessarily much smaller, on account of the shattered state of the chalk, these shafts are comparable to those of Grimes Graves, which they resemble in having been hewn out with stag's horn picks. The implements and scrap from the sites, however, do not closely resemble those from the English locality, and seem to show that these mines were worked from the later part of the Neolithic to the Early Iron age.

The third work under review is an excellent piece of archæological survey, detailing the camps and graveyards, the rock-shelters and trails of the Red Indians in certain parts of New Jersey. It consists of a mass of facts well illustrated by maps, plans of rock-shelters, and photographs of pottery, of great local interest, but impossible of review. It is, however, an illustration of the interest which citizens

[1] Professor T. McKenny Hughes, "Flints": Cambridge Ant. Soc. Coll., vol. xviii.

Dr. N. O. Holst, "The Swedish Flint Mines": Report on the Excavations at Grimes Graves, 1914.

M. Schrabisch, "Indian Habitations in Sussex County, New Jersey"; and L. Spier, "Indian Remains near Plainfield, Union Co., and along the Delaware Valley": Geol. Surv. New Jersey, Bull. 13, 1915.

N. H. Winchell, "The Weathering of Aboriginal Stone Artifacts. No. 1. A consideration of the Palæoliths of Kansas": Collections of the Minnesota Historical Society, vol. xvi, pt. i.

of the United States feel in the history of their country, and the thoroughness with which they are recording the fast vanishing remains of the splendid savages whose place they have taken.

The last archæological work which it falls to me to review claims to deal with the Palæoliths of Kansas. The author divides up a series of implements into four groups, two said to be of Palæolithic age, the others later and early Neolithic. He correlates them with the many glaciations of North America. All these specimens seem to be surface finds. None were found with extinct animals or in relation to glacial deposits. The whole scheme rests entirely on depth of patination and on certain implements which are said to be rechipped. Some of the implements photographed do resemble genuine palæoliths in shape, but others are as obviously allied to modern Indian work.

The whole book is a somewhat pathetic example of misapplied energy. There is not the slightest evidence that any one of the American implements described was made during the Ice Age or before it. So far as I know, only one implement has been found in America that has any claim at all to be considered a palæolith, the arrowhead found by Professor Williston in association with an extinct bison; and this is of a relatively modern Indian type.

III.—The Pleistocene Mammals of Iowa. By O. P. Hay.[1]

THIS paper consists of 499 pages of text and 75 plates, mostly from photographs. It begins with a very valuable account of the main facts of the glacial geology of Iowa, describing the distribution of the tills laid down during five glacial stages and of the deposits associated with the interglacial intervals. This section is provided with an elaborate bibliography.

The second part of the paper gives in as untechnical a way as possible, descriptions of the animals found in the Pleistocene of this State, together with some that will no doubt be found in the future. These descriptions are founded on Iowan specimens, but when these are incomplete others are figured and their measurements given. The whole forms a very valuable work of reference, full of clearly arranged facts, but does not seem to contain any general conclusions as to the relations of the many animals discussed to the divisions of Pleistocene time; in fact, the existing collections seem to be still too small to yield much in the way of wide generalizations.

IV.—The Coal-measure Amphibia and the Crossopterygia. By R. L. Moodie.[2]

IN this short paper Dr. Moodie gives a phyletic tree of the vertebrates, of interest as representing the views of a student with great knowledge of the smaller Coal-measure amphibia, still unfortunately so very incompletely known. He then gives a short summary of the geological history of the amphibia, which is slightly

[1] Iowa Geological Survey, vol. xxiii, 1914.
[2] The American Naturalist, vol. xlix, p. 637.

incomplete in not recording the amphibia from the Mississippian of Scotland and the frog from the lithographic slate of Portugal.

A comparative table shows that in many features the Crossopterygian fish and the amphibia approach one another. Finally, the high degree of specialization and complete adaptation to nearly all conditions of vertebrate existence of the Coal-measure amphibia is insisted upon.

V.—New York State Museum. Palæozoic Fishes, etc.

RESTORATIONS of *Bothriolepis* and *Cephalaspis* as restored by Patten and modelled by Marchand are figured as among the new items on exhibition in New York. The State mining exhibit at the Panama–Pacific Exposition is described, and a report is given on the preservation of natural monuments. These latter, now added to the former trusts, are the Lester Park (or the "*Cryptozoon* Ledge"), Stark's Knob, a dome-shaped volcanic knoll, the Clark reservation (a glacial park), Logan Park (where W. E. Logan began his official work) with its vertical ledge of Ordovician or Cambrian limestone-conglomerate, and the Hugh Miller Cliffs, Scaumenac Bay, celebrated for their Old Red fishes. All these places are briefly described in the Museum Bulletin 177 of the New York State Museum, 1915. This Bulletin also contains, we believe for the first time, an excellent attempt at depicting a geological section by colour photography. There is a short paper by Hudson on *Porocrinus*; others by Clarke on American Devonian, the Oriskany, and the Rifted-Relict-Mountain; and by Miller on Trenton Contortions and the Rift on Chimney Mountain. Among accessions we note the Silas Young minerals.

VI.—Structure of the Trilobite *Harpes*.

IN preparation for a monograph on the trilobite *Harpes*, Dr. Rudolf Richter has studied the structure by means of thin sections, and has presented an outline of his main results in *Zoologischer Anzeiger* (vol. xlv, pp. 146–52, Dec. 1914). He finds that the pits on the brim (French 'limbe', mistranslated as 'limb' by several English writers) are not blind, as stated in text-books, but pierce right through. Precisely the same structure extends over a considerable tract of the swollen part of the head-shield. All this perforate extension is composed of two distinct layers (outer and inner) of chitinous integument. From the inner boundary of the inner layer a thin ventral membrane extends below the true head cavity. The marginal suture (on the outer edge of the brim) has been regarded as the ocular suture, and the under fold of integument as the free cheeks; and on this view depended Beecher's conception of the Hypoparia. A corollary of that view was that the eyes on the upper surface could not be homologous with the true eyes of other trilobites. Richter, however, shows that the microscopic structure is quite opposed to that forced hypothesis. The eyes are true eyes, and though the ocular suture is obscured the free cheeks occupy the normal position. The marginal suture is, in his opinion, a special

development to permit the separation of the under layers of integument in course of moulting, and traces of this division between the two layers, though sought in vain by some previous writers, have been found by him on the sides of the perforations. Consequently *Harpes*, *Trinucleus*, *Dionide*, and the rest, though highly specialized, are not essentially different from other trilobites, a view which accords with that expressed by Professor Swinnerton in the GEOLOGICAL MAGAZINE for November, 1915. Dr. Richter also elucidates the peculiar method of rolling up the carapace, and believes that the backwardly directed horns of the head-shield served, not as 'mud-shoes', but as balancers when the animal swam; a similar balancer-function has been ascribed to the horns of *Ceratocystis*, *Cothurnocystis*, and *Dendrocystis* (see GEOL. MAG., Sept. 1913, plate xiii).

VII.—STUDIES IN EDRIOASTEROIDEA, I–IX. By F. A. BATHER, M.A., D.Sc., F.R.S., etc. 8vo; pp. 136, with 13 plates. Published by the author at "Fabo", Marryat Road, Wimbledon, London, S.W. 1915. Price 10*s.* 6*d.*

THIS highly important work, completed in the past year, was begun as a series of articles in the GEOLOGICAL MAGAZINE in 1898 and continued, with intervals, until 1915, extending over seventeen years. In the reprinted form there will be found some valuable additions, and the very numerous illustrations in the text, as well as the thirteen beautiful plates, are all reproduced with care. To any student desirous to become acquainted with the morphology and classification of the Echinoderma the present work must form an essential part of his library; and as the original "Studies" are scattered through the volumes of the GEOLOGICAL MAGAZINE during so many years, we must all feel extremely grateful for the "Author's Edition", as Dr. Bather calls this volume.

We heartily congratulate the author upon his completed work, and wish him many more years in which to continue his difficult but delightful studies of other sections of the Echinoderma.

VIII.—CATALOGUE OF TYPES AND FIGURED SPECIMENS OF BRITISH CRETACEOUS LAMELLIBRANCHIATA PRESERVED IN THE MUSEUM OF PRACTICAL GEOLOGY, LONDON. Summary of Progress of the Geological Survey for 1914, Appendix II, pp. 66–79, 1915.

MR. H. A. ALLEN, F.G.S., one of the Palæontologists of the Geological Survey, is the compiler of this very excellent and useful work. It forms the eighth of a series of similar lists which have been issued under the same auspices, the previous subjects treated being Eocene and Oligocene (1900); Pliocene, Pleistocene, and Devonian (1901); Phyllocarida and Palæozoic Echinodermata (1902); Rhætic, Lias, and Inferior Oolite Gasteropoda (1903); Great Oolite, Cornbrash, and Corallian Gasteropoda (1904); Rhætic and Lias Lamellibranchiata (1905); Lower, Middle, and Upper Oolite Lamellibranchiata (1906). These catalogues are all modelled on the same plan, the genus and species of each entry standing out clearly in a bold black type, followed by the author's name, beneath

being the reference in literature where the description and figures are to be found, and afterwards are given the geological horizon, locality, and registration number. A valuable addition, we think, might have been introduced in connexion with the geological information offered, that of Continental equivalents, as for instance, when quoting the horizon of the Atherfield Beds as 'Lower Greensand' the term 'Barremian' might have been given in brackets. A modification of this kind would have been most welcome to the foreign student of geology in enabling him at once to understand the value of a purely English term and its exact significance in the Cretaceous Series. It is interesting to mention that this catalogue differs from all the former, as it includes a number of type or figured specimens that were originally in the Museum of the Geological Society of London, these being indicated by the letters G.S.

R. B. N.

IX.—Isostasy, and the Asthenosphere.

The Strength of the Earth's Crust. By Joseph Barrell. Journal of Geology, vol. xxii, pp. 28, 145, 209, 289, 441, 537, 655, and 729, 1914; vol. xxiii, pp. 27, 424, and 499, 1915.

IN this remarkable series of papers, which is worthy of the most careful study, Professor Barrell discusses the problems arising from the existence, now well established, of isostasy. He shows from geodetic data and from geological evidence (e.g. the building up of extensive deltas) that "isostasy . . . is nearly perfect, is very imperfect, or even non-existent according to the size and relief of the area considered". The close degree of isostatic equilibrium postulated by Hayford is not admitted, but since over large areas equilibrium is maintained in spite of denudation, deposition, and mountain-building, it follows that there must be some counter movement taking place within the earth. To explain the mechanism of isostatic compensation Barrell introduces the conception of an *asthenosphere*—a sphere of weakness—which, as he clearly shows, must be *below* the level of compensation, and of great thickness. The excess pressure of heavy columns of the lithosphere is transmitted to the asthenosphere, within which the lateral movements of restoration take place. In proof of the existence of some such zone of weakness the author indicates the impossibility of widespread flowage in the zone of compensation; he shows that below the level of compensation the earth is unable to withstand the stresses thrown upon it by the greater undulations of topographic relief; and finally he cites Schweydar's conclusion, based on measurements of earth tides, that there seems to exist a yielding layer 600 kilometres in thickness below the 120 kilometres of the lithosphere.

It is suggested that recrystallization is the chief factor determining weakness, plasticity, and flowage. It should be remembered that effective plasticity, signifying a low elastic limit, is by no means incompatible with a high rigidity. The flowage of glaciers is an instructive case in point. Recrystallization will clearly be favoured by high temperature conditions. This leads to another line of

argument supporting the existence of the asthenosphere, for the distribution of the radio-elements in the earth's crust carries with it the deduction that fusion temperatures (under high pressures) can only be approached far below the level of compensation, probably 200 km., or more, below. In keeping with this view, Barrell holds on mechanical grounds that the source of igneous activity is well within the asthenosphere. Recrystallization, culminating in local fusion, is brought about by the gradual contact of the temperature curve with the fusion-solution curve, and "if this is the cause of the disappearance of strength, it should be as much as 300 km. deep and extend through some hundreds of kilometres". The author draws a short sketch of the initiation of magmas and their ascent into the crust. He supposes that they are of basaltic or andesitic composition, though in the opinion of the present writer the possibility of the rocks at such depths being wholly of ultra-basic composition is worthy of consideration, together with the mechanism of igneous intrusion implied by that view.

Professor Barrell's papers constitute a valuable and stimulating contribution to terrestrial dynamics, only the fringe of which has been touched upon in this brief and therefore inadequate review.

ARTHUR HOLMES.

X.—Delta Deposits of the Nile.

THE SUBSOIL OF CAIRO. By E. C. BOWDEN SMITH. Cairo Sci. Journ., Nos. 97 and 98, vol. viii, pp. 239–50, with 3 plates, 1914.

ONE of the most interesting problems connected with the delta deposits of the Nile is their evidence on the supposed isostatic movements of the area; and Mr. Bowden Smith discusses the evidence of many bores under the Nile delta upon the supposed subsidence. He quotes Professor Watts to the effect that the old soils, one below another, prove conclusively the repeated subsidence of the delta, and he remarks that according to other authorities the low-level deposits at least were laid down beneath the sea when it extended southward up the Nile Valley. Mr. Smith states that the delta is not composed of an endless succession of interlaced deposits of sand and clay; he concludes from the nature of the deep-level deposits and their irregular distribution there is reason to believe that they were formed by river-action working under conditions similar to those that prevail on the surface at the present day. The author remarks that the evidence on this question is not conclusive, and that some of the deep-level material may be marine, but he holds that repeated substances have taken place between long intervals of rest.

J. W. G.

XI.—DOELTER'S HANDBOOK OF MINERALOGY.—We recently received the fourth part (Dresden and Leipzig: Theodor Steinkopff. Price 6.50 marks) of the third volume of the comprehensive *Handbuch der Mineralchemie*, edited by Professor C. Doelter, which was issued in July, 1914, just before the outbreak of War. It forms the penultimate part of the volume, and in its 160 pages deals with the

concluding species among the phosphates and with the greater number of arsenic compounds. A conspicuous feature of the work consists of the ample discussion of chemical methods which are introductory to the descriptions of the principal mineral groups; thus, in the present part we find an able article from the pen of Professor Dittrich on the analysis of the arsenates. The descriptions of the several species seems on the whole complete and up to date. We have under turquoise a good account of Schaller's recent work on the specimens found in Virginia, which cleared up the mystery of the crystallization of that species and showed it to be isomorphous with chalcosiderite. Following the chapters on monazite and xenotime comes an interesting one on the commercial use of the so-called rare earths. We have noticed one important omission. In the section on tilasite, the calcium-magnesium arsenate, no reference is made to the memoir published by Prior & Smith in the *Mineralogical Magazine* in 1911 on the crystals found by Ferrar in the manganese-ore deposits of Central India. In consequence the crystallographical particulars of the mineral are reduced to the single—erroneous—sentence: "Kristallisiert vielleicht triklin"; the crystals, however, actually belong to the clinohedral class of the monoclinic system.

XII.—Russian Meteorite.—In the Proceedings of the U.S. National Museum (vol. xlix, pp. 109–12, with plate xxxvii) Mr. George P. Merrill briefly describes the meteoric stone which fell at Indarch in Russia on April 7, or possibly April 9, 1891. It is a dark greenish-grey in colour, firm and compact in texture, and thickly studded with small, dark-green chondrules and nodular masses of metal and troilite, rarely more than 1 mm. in diameter. Graphite is very prevalent. Oldhamite, calcium sulphide, occurs sometimes interstitial and sometimes enclosed in enstatite; it is yellow-brown, sometimes greenish, in colour, and completely isotropic. The presence of carbonic acid in the analysis suggested breunnerite, but the actual occurrence could not be determined. The stone is a carbonaceous chondrite (Kc).

XIII.—Brief Notices.

1. Quinquennial Review of the Mineral Production of India. By Sir T. H. Holland and Dr. L. L. Fermor. Revised for the years 1909 to 1913 by Dr. H. H. Hayden and Dr. L. L. Fermor. Records Geological Survey of India, vol. xlvi, 1915.

This valuable report contains a great deal of useful information regarding the occurrence of economic minerals in India. Listed according to their values the eight principal minerals are coal (£3,800,000 in 1913), gold, petroleum, manganese ore (about 40 per cent of the world's production, and exceeded only by Russia), salt and saltpetre, mica (65 per cent of world's production), and lead ores. During the period under review the tin and wolfram industries in Lower Burma have made considerable strides, while rubies and other precious stones have suffered some depression. The

production of monazite from the seashore of Travancore marks the commencement of a new mineral industry.

2. On the Porosity of the Rocks of the Karroo System in South Africa. By A. L. du Toit. Trans. Roy. Soc. S. Africa, vol. iv, pt. iii, pp. 169–80, 1915.

The rocks of the Karroo system cover fully one-half of the Union of South Africa, and have sometimes been considered capable of furnishing important supplies of artesian water. The author has made a large number of measurements of porosity and specific gravity on fresh specimens from various horizons of the formations represented. His results show that the porosity of these rocks is low, and that, except where fissures and joints increase the capacity for water storage, strong supplies cannot be anticipated.

3. Brighton's Lost River.—Mr. E. A. Martin has contributed to the Transactions of the South-Eastern Union of Scientific Societies, 1915, a very complete account of the Wellesbourne, a stream which rose near the upper end of Patcham Street and entered the sea at the Pool, Pool Valley, Brighton. Its operations are now confined by a sewer, but in former days it seems to have been the cause of frequent flooding and other trouble to the town.

REPORTS AND PROCEEDINGS.

I.—Geological Society of Glasgow.

At a meeting of the above Society held on November 11, the office-bearers for the session were elected.

Mr. Alexander Scott, M.A., B.Sc., read a paper on "Primary Analcite and Analcitation". He discussed the occurrence and form of analcite in igneous rocks and reviewed the opinions of various authorities concerning it. British and American petrologists generally favour the opinion that the mineral is primary, while Continental investigators hold the view that it is secondary. The chief evidence in favour of the latter theory is the altered condition of associated minerals, but this can be shown to be due to reactions between the analcite and minerals previously formed; thus felspar is replaced by analcite, augite has a rim of soda-pyroxene, and olivine and magnetite are surrounded by biotite. These undoubtedly arise by the corrosion of the early minerals by a magmatic residuum rich in water and soda. The general conclusion is that analcite is primary in many rocks, particularly in the great Permo-Carboniferous suite of the West of Scotland described by Tyrrell.

Professor Gregory complimented the author on his paper, and said it was satisfactory to find that, while there was ground for the views of both the British and the Continental workers, the balance of truth lay with the British.

Mr. G. W. Tyrrell said that in addition to the evidence brought forward by Mr. Scott, the fact that analcite is such an important constituent (sometimes about 40 per cent) of many rocks points to its being a primary ingredient, as such rocks, minus their analcite,

would be too spongy in structure to resist the pressures to which they had undoubtedly been subjected. He also compared its mode of occurrence with that of quartz in a granite, and thought that the two were quite analogous.

Mr. Peter Macnair, F.R.S.E., F.G.S., read a paper on "The Horizons of the Type-specimens of *Dithyrocaris tricornis* and *D. testudinea*". He detailed what was known as to the discovery of these interesting fossils, and pointed out that, while the facts connected with the East Kilbride occurrences were well ascertained, there was confusion with regard to the exact locality from which the Paisley specimens came and their horizon was not known. He stated that he had recently found specimens in an old dyke and an old house built of a peculiar limestone near Arklestone, Paisley, and showed that this material must have come from certain old quarries, now obliterated, and that these quarries must have been opened in the Blackbyre Limestone.

Mr. R. G. Carruthers, H.M. Geological Survey, said that he quite agreed that these specimens must have come from a peculiar bed lying at the top of the Blackbyre Limestone at Arklestone, and congratulated Mr. Macnair on having settled a question that had been for so long a source of discussion.

II.—Geological Society of London.

1. *November* 17, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

Mr. John Parkinson gave an account (illustrated by specimens and lantern-slides) of the Structure of the Northern Frontier District and Jubaland Provinces of the East Africa Protectorate, made by him while conducting a water-supply survey for the Government of the Protectorate. A floor of gneisses and schists, among which the Turoka Series of metamorphosed sediments was found at several places, is overlain on the western side by lavas, including those arising from the volcanoes Kulal, Assi ('Esie' of the maps), Hurri, Marsabit, etc., and by probably older lava-fields, which together extend as far as long. 39° E. On the south, it was found that the lavas north of Kenya reached the Guaso Nyiro, leaving 'inselberge' of the crystalline rocks in their midst, but that a high gneiss country extended north-westwards from lat. 1° N. and long. 38° E. to within a short distance of Lake Rudolf. Eastwards the Coastal Belt of sediments proved to be of Upper Oxfordian age and to extend to long. 40½° E. (west of Eil Wak), and these were lost southwards under the great alluvial plain of Jubaland.

At intervals throughout the alluvial plain and lying in hollows in the Jurassic rocks, disconnected exposures were found of soft calcareous sandstones or limestones (Wajhir, Eil Wak), the age of which cannot now be definitely fixed.

Evidences of the desiccation of the country were, it was thought, shown (1) by the Laks or water-channels characteristic of Jubaland, which contained surface-water only during the rainy season and then

extremely rarely, if ever, throughout their length; (2) by the presence of freshwater molluscs in the scarcely consolidated beds of such Laks and at other places where now no surface-water is present (Buna and near the Abyssinian frontier); and (3) by the presence of wells along fault-lines and in other places where, but for the previous presence of springs, it appears improbable that the natives would have begun sinking.

The region between Lake Rudolf and Marsabit was pointed out as one of exceptional interest, which the speaker had so far not been able to investigate.

The depression between the Mathews and associated ranges and the Abyssinian frontier on which the Marsabit and Hurri volcanoes were situated, and the origin of the Kuroli Desert (Elgess), were the outstanding features of the district that required further elucidation.

Mr. G. C. Crick stated that the Cephalopoda submitted to him by Mr. Parkinson consisted chiefly of crushed ammonites from dark-grey shales at Kukatta on the Juba River (lat. 2° 8′ N.), there being also a belemnite preserved in a yellowish-brown rock-fragment from Serenli on the same river and somewhat north of Kukatta. He concluded that the shales at Kukatta were of Upper Oxfordian (Sequanian) age.

Mr. R. Bullen Newton had examined a small series of non-marine Kainozoic molluscan remains belonging to recent species, and associated with hard and soft limestones, calcareous sandstones, and conglomerates, which had been collected by Mr. Parkinson, and had determined about nine genera and twelve species. No vertebrates occurred with these shells, hence their age would probably be younger than the Omo-River deposits north of Lake Rudolf, and that yielded a somewhat similar molluscan fauna, but with the addition of *Dinotherium* and other vertebrate remains. The presence of that genus, as pointed out by Dr. Haug (*Traité de Géologie*, 1908–11, vol. ii, p. 1727), was indicative of the Pontian or Upper Miocene Period. There are, however, some lacustrine beds near Lake Assal, in French Somaliland (formerly regarded as Abyssinia), which contain shells also bearing a resemblance to those collected by Mr. Parkinson in British East Africa, especially *Melania tuberculata*, *Cleopatra bulimoides*, *Corbicula fluminalis*, and *C. radiata*, which are common to both sets of deposits. These Lake Assal beds, which are also without vertebrate remains, have been identified by Aubrey (Bull. Soc. Géol. France, ser. III, vol. xiv, pp. 206–9, 1885), and Pantanelli (Atti Soc. Toscana Sci. Nat. Proc.-verb., vol. v, pp. 204–6, 1887, and ibid. vol. vi, p. 169, 1888) as of Pliocene age. If, from these facts, such widely distant beds can be recognized as contemporaneous, then the suggestion may be made that the northern half of British East Africa was probably an extensive freshwater region during Pliocene times, limited on the north by Lake Assal, on the east by Suddidima, on the south by Archer's Post and the Mount Kenya plateau, and on the west by Lakes Rudolf, Stefanie, and Marguerite.

Assistance in the determination of these shells had been kindly rendered by Mr. E. A. Smith, I.S.O.

2. *December* 1, 1915.—Dr. A. Smith Woodward, F.R.S., President, in the Chair.

The President exhibited lantern-slides lent by Professor Elliot Smith to illustrate the fossil human skull found at Talgai, Darling Downs, Queensland, in 1914. The specimen was brought to the notice of the British Association in Sydney by Professor T. W. Edgeworth David, and would shortly be described by him and Professor Arthur Smith. It was obtained from a river-deposit in which remains of *Diprotodon* and other extinct marsupials had already been discovered, and there could be no doubt that it belonged to the Pleistocene fauna. It therefore explained the occurrence of the dingo with the extinct marsupials. The skull is typically human and of the primitive Australian type, but differs from all such skulls hitherto found in possessing relatively large canine teeth, which interlock like those of an ape. The upper canine shows a large facet worn to its base by the lower premolar. The discovery of the Talgai skull is, therefore, an interesting sequel to that of Mr. Charles Dawson's Piltdown skull, in which the canine teeth are even more ape-like.

Dr. J. W. Evans discussed the different methods of obtaining the directions-image ("interference figures") of a small mineral in a rock-slice, unaffected by the light from neighbouring minerals. He preferred the use of a diaphragm in the focus of the eye-piece, in conjunction with a Becke lens.

He also described the inferences that might be drawn from the form, position, and movement on the rotation of the stage of the isogyres (dark bars or bushes) in the directions-images, both of chance sections and those cut parallel to planes of optical symmetry or at right angles to optical axes. He showed how the character or sign of the crystal and its approximate optic axial angle might be determined.

III.—Mineralogical Society.

Anniversary Meeting, *November* 9, 1915. W. Barlow, F.R.S., President, in the Chair.

W. Barlow: Crystallographic relations of allied substances traced by means of the law of valency volume. The ordinary parameters of a crystal do not necessarily express the actual ratio between the minimum translations of the crystal structure, and it is justifiable to multiply one or sometimes two of them by a small integer in order to obtain the equivalence parameters. A number of cases were taken which showed that in crystals which either contain the same radicle or closely related radicles the similar parts are arranged in identical strata intercalated between the remaining constituents of the crystal. A. F. Hallimond: On Torbernite. From measurements made on several specimens the axial ratio $a : c = 1 : 2{\cdot}947$ was determined, and the forms 001, 101, 103, 111, 112, besides vicinal faces, were observed. The mineral becomes unstable at vapour-pressures about one-third that of water, and passes into Rinne's meta-torbernite I. At higher temperatures the transition-curve rises sharply, and meets the vapour-pressure curve of water at 75° C., above which torbernite has no stable existence in air. T. V. Barker: On the solution

of the problem of Four Tautozonal Poles. The indices of two poles C, D may be expressed as functions of those of the two other A (*abc*), B (*def*) in the form $(pa+qd, pb+qe, pc+qf)$, $(ma+nd, mb+ne, mc+nf)$ where p, q, m, n are small positive or negative integers. Since $npcotAD=(np-mq)cotAB+mqcotAC$, a table of natural cotangents enables a numerical example to be solved rapidly. Usually $p=q=1$, and the equation reduces to $ncotAD=(n-m)cotAB+mcotAC$. L. J. Spencer: Crystals of Iron Phosphide (Rhabdite) from a Blast-furnace. The small, acicular, tin-white, and strongly magnetic crystals were found sparingly in cavities in a large mass of metal at the bottom of a blast-furnace near Middlesbrough. They are tetragonal (sphenoidal-hemihedral) with the axial ratio, $a:c=1:0{\cdot}3469$. Dr. G. T. Prior: The Meteoric Stone of Cronstad Orange Free State.

At the above meeting the following officers and members of Council were elected: President, W. Barlow, F.R.S.; Vice-Presidents, Professor H. L. Bowman and A. Hutchinson; Treasurer, Sir William P. Beale, Bart., K.C., M.P.; General Secretary, Dr. G. T. Prior, F.R.S.; Foreign Secretary, Professor W. W. Watts, F.R.S.; Editor of the Journal, L. J. Spencer; Ordinary Members of Council, Dr. J. J. Harris Teall, F.R.S., F. N. Ashcroft, Professor H. Hilton, Arthur Russell, W. Campbell Smith, Dr. J. W. Evans, Dr. F. H. Hatch, J. A. Howe, T. V. Barker, G. Barrow, Dr. C. G. Cullis, and F. P. Mennell.

CORRESPONDENCE.

"ON CERTAIN CHANNELS."

Sir,—A section of Professor Bonney's recent essay *On certain Channels attributed to overflow streams from ice-dammed lakes*[1] is devoted to an extremely courteous criticism, but final rejection, of my interpretation of glacial phenomena in the Black Combe area.[2] Since he advances an alternative hypothesis to account for the above-mentioned channels, I am sure he will pardon me if I, in my turn, offer a few critical remarks.

I must first protest against Professor Bonney's assumption (*vide* title of his paper) that I ascribe practically all these channels to overflow waters from ice-dammed lakes. In many cases, as I clearly state, they were merely carriers of the normal marginal drainage of an ice-sheet. Nor do I invent ice-dams "almost by the dozen". As regards overflows from lakes, one dam—the Irish Sea Ice—is quite sufficient.

In my description the drainage channels are discussed and interpreted in the light of observations, recorded on 6 in. field maps, and fall into place as an important chapter in the glacial history of the area. Professor Bonney states that he accepts most of my facts, but differs from my conclusions; yet, having made this admission, and agreeing that land-ice "occupied all this district during some part of the Ice Age", he appears to ignore the evidence

[1] Published by Bowes & Bowes, Cambridge, 1915.
[2] Q.J.G.S., vol. lxviii, 1912.

relating to the composition, character, and location of the glacial drifts, as well as that furnished by erratics, ice-moulded surfaces, and striæ.

Having thus divorced these anomalous channels from their surroundings, he has constructed a theory to explain their origin (as it seems to me) based chiefly upon their shape and rate of fall.

If land-ice "occupied all this district during some part of the Ice Age", and there was no Irish Sea Ice, I venture to ask why (as its markings show) the ice from Eskdale first turned south, along the seaward slope of Black Combe, and then swung to the east and north-east into the mouth of the Duddon estuary; and why the Whicham Valley Ice, moving first in a south-westerly direction, was also directed towards the south-east and east near the mouth of that valley? Why did it not ride out to sea? What was the impelling force that turned it aside?

Professor Bonney doubts whether marginal streams could cut channels in granite in a short time. He may read of recent examples described by Von Engeln,[1] to whose article I have already made reference.

My critic admits that the systems of parallel trenches on the west coast, as contrasted with the preglacial drainage, are abnormal in direction, and finds some difficulty in explaining this anomaly, but confesses himself happier when dealing with the channels east of Black Combe, where "the trenches take a more normal course". The explanation is simple: in the first case the trenches were marginal to the Irish Sea Ice, and are therefore transverse to the normal drainage, whereas in the second case they were marginal to the local Lake District glaciers which occupied the present drainage lines at a late stage of the glaciation. If, as Professor Bonney maintains, the dry channels on the west coast are preglacial, how does he explain the presence of thick glacial drift upon the ground between them, and upon the higher inland slopes, but not within them?

Perhaps the weakest part of this new hypothesis is an attempt to explain the 'in-and-out' channels by marine erosion of the seaward wall. A preglacial submergence cannot be invoked, because one of the long 'in-and-out' channels (Monk Foss) is cut entirely in glacial drift; nor can we admit a postglacial submergence, for that would have entirely destroyed the typically hummocky character of the drift on the plain between Millom and the mouth of the Esk. Moreover, even were 'in-and-out' channels at this spot due to marine erosion, we cannot explain in this manner the 'in-and-out' channels of other districts far from the sea.

Finally, one might pertinently ask how pre-Triassic valleys could have maintained such sharp well-defined contours to this day. As a field-geologist I have frequently noticed the "half effaced features of an earlier topography", but in few instances have I seen anything more blatantly modern in appearance than these marginal or overflow-channels in the Black Combe district, or, indeed, in North Wales, where they are cut in fairly soft shales.

[1] "Phenomena associated with Glacial Drainage and Wastage": Zeit. Gletscherkunde, vol. vi, pp. 126–31, 1911.

This conception of old drainage systems running parallel to the contours of the mainland, in Cumberland, Haddingtonshire, S.E. Ireland, Denbighshire, Flintshire, etc., when coupled with the warping movements necessary to explain the steep fall of the channels, sets the mind, no less than the land, awhirl.

BERNARD SMITH.

THE GEOLOGICAL AGE OF THE CARRARA MARBLES.

SIR,—Permit me to comment briefly on Dr. Du Riche Preller's paper on the Carrara Marble District.[1] It contains a quantity of interesting information, topographic and economic, but does little, in my opinion, to settle the question as to the age of those rocks or strengthen the position of the Italian geologists. I had their map with me in the autumn of 1889, and in regard to faults (which Dr. Preller considers to be almost negligible) wrote thus in my diary: "In order to accept the geological succession they have indicated, we must explain the proximity of ordinary dark mechanically disturbed limestone (just like some of that at Spezzia) with lighter varieties to perfectly typical Carrara marble." I was aware that the statuary marble is intercalated with marbles of inferior quality, but instead of finding any sign that the metamorphism was a result of pressure, maintain that, as shown by the microscope, that marble has escaped (as I stated) from the crushing which has affected its associates. As to 'metamorphism' and its effect on sedimentary rocks, I have been doing my best to study the whole question since about 1875, have spent much time and money in examining alleged passages from crystalline schists to comparatively unaltered sediments or intercalations of the two, with the invariable result that the evidence was never conclusive and very commonly worthless; in fact, I have not been able to discover any case (I have not restricted myself to the Alps) where a truly crystalline limestone, such as that of Carrara, is in stratigraphical sequence with a sedimentary rock to which a date can be assigned on the evidence of fossils, except in the case of contact metamorphism, which, so far as I am aware, is not exhibited in the Apuan Alps. Dr. Preller's paper contains no evidence that he has made use of the microscope in studying these Carrara rocks, and as I know the vague use of the term 'schist' by many Continental and some British geologists I am unable to discuss his sections (Figs. I–IV) beyond saying that only one of them seems to demand an explanation, and this I think my past experience would enable me to supply.

T. G. BONNEY.

RENÉ ZEILLER—MASTER PALÆOBOTANIST.

SIR,—In the current number of *Nature* there is a short tribute by Professor Seward to Professor Zeiller, whose death this week in Paris we all deplore. I should like to add a word in token of the deep and lasting affection and reverence the great Palæobotanist inspired in his younger colleagues in many countries.

[1] GEOL. MAG., December, 1915, pp. 554–65.